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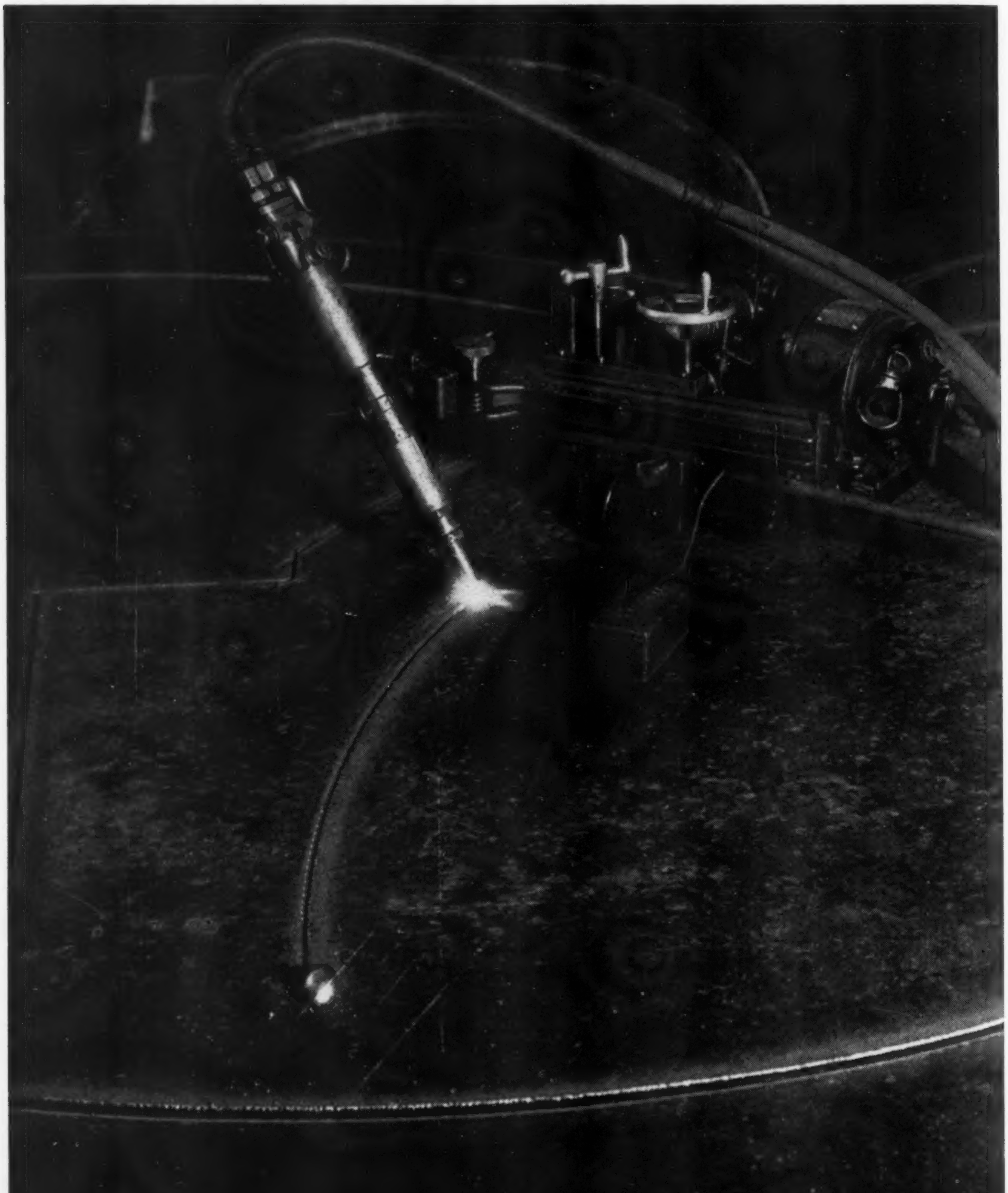

Galloway, N. Y.

Cutting Steel Plate With a Gas Torch

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SEPTEMBER
1941

GEORGE A. STETSON, *Editor*

War on Waste

WHAT happens when materials run short and the government assumes control of supplies to insure its own needs has been well illustrated by the silk-stocking seriocomedy.

But silk is only one commodity. Of the aluminum shortage most persons are conscious because of the drive to collect battered pots and pans. The situation in copper is more recent and not so well known. Steel, in spite of our vast production capacity, was placed under 100 per cent priority control by OPM on August 9. Tin, lead, zinc, tungsten, rubber, cork, chromium, nickel—the list is long—are available in quantities insufficient for nondefense needs after defense requirements have been met. The glut of overproduction that worried some economists a few years ago suddenly becomes an alarming shortage as the most stupendous defense program ever attempted swings into its stride and jostles nondefense supply out of its way.

Faced with this serious shortage of materials OPM officials are enlisting the support of the public in general and engineers in particular in a war on waste to be fought on the five fronts: Conservation, substitution, reclamation, simplification, and specification. Engineers will recognize at once that they are primarily concerned on each of these fronts and that their ingenuity has been challenged. With everybody thinking about the problem and doing something about it we may not only find that shortages can be made less acute but that better material uses and worth-while economies in peacetimes can be discovered. That serious industrial and market dislocations may result from shortage and substitution cannot be denied. The engineers' problem is to make the effects as harmless as may be. Much is being done. To cite but two examples, a notice in the A.S.M.E. News section of this issue tells of reports to be issued on the substitution of molybdenum for tungsten; and a recent announcement of the International Nickel Company offers the assistance of the company's research staff to users of nickel in solving problems of substitution.

The engineering societies' contribution to nation-wide effort in conservation and substitution of defense materials has recently been initiated in the formation of the Engineers' Defense-Materials Board on which more than a half-dozen societies, including the A.S.M.E., are represented. The function of this board has been stated as follows:

"In the interest of conservation of all industrial materials to aid defense production by selecting substitutes, eliminating waste, simplifying specifications and standards, and improving design techniques:

"1 To become aware of the present and possible material shortages.

"2 To encourage engineers in industry and in government to the necessary steps to overcome these shortages, stimulating research where necessary.

"3 To disseminate information among engineers throughout the industry about the successful solution of shortage problems."

As this issue goes to press this board is being organized. The caliber of its membership is guarantee of its usefulness and its ability to perform the function assumed by it. Surely, if engineers, under the leadership of Herbert Hoover when he was Secretary of Commerce and with the backing of the American Engineering Council could make a comprehensive study of the problem of waste and issue a voluminous report on "Waste in Industry" in 1921 when the world was at peace, they can find practical solutions to materials shortages under the spur of urgent necessity. OPM officials count heavily on engineer leadership and ingenuity and on popular support. They will not be disappointed. Every person would do well to keep constantly in mind that doggerel which, imperfectly remembered, perhaps, runs "Use it up; wear it out; make it do; go without."

Industrial Research

THE report of the National Research Council on "Industrial Research," recently transmitted to the Congress by the National Resources Planning Board and made public, reflects the opinions that the United States has become "the acknowledged leader in industrial research" and that industrial research has become a "major national resource." Partial substantiation of these opinions is found in the statement that industry in this country employs more than 70,000 workers in more than 2200 laboratories at an estimated annual cost of $300,000,000.

On the question, What constitutes industrial research? Harvey N. Davis and C. E. Davies, past-president and secretary, respectively, of The American Society of Mechanical Engineers, in a portion of the report entitled "Industrial Research by Mechanical Engineers," say:

"The writers of this report suggest for the consideration of those interested in industrial research that everything that anybody in industry does in the course of his daily work is either routine or research."

This definition is sufficiently broad to clarify the confusion of meaning of the term that appeared to exist in the minds of many who were appealed to in the survey of

the mechanical-engineering field undertaken by these writers in the preparation of their contribution to the report. It broadens the view taken by many that would confine research to the investigations of a few specialists on the frontiers of the physical sciences and makes it possible to include almost any form of search for truth and understanding by that powerful tool, the scientific method. It also serves to bring close to laymen a practical view of inquiries which may have a commonplace origin and purpose and lie in fields not confined to the laboratory but in shop, office, and market place as well. Growing faith in research and acceptance of it as a valuable aid to human progress and everyday affairs, noted in the report, are also accelerated by such a view.

It is becoming pretty generally recognized that research is not only a national resource, but a means of salvation as well. No one needs to have pointed out to him that research lies at the base of the advantages one nation may possess over another in its instruments of war and its techniques of offense or defense. Demands of reconstruction and return to peacetime pursuits, with which will appear also problems of unemployment, standards of living, international trade, and what we are pleased to call the progress of civilization, will unquestionably put research to greater tests of its value than it has ever before been forced to face. Hence popularization of research, broader understanding of what it is and what it can accomplish, and removal of often expressed fears of its adverse effect on the problems it is most competent to solve are obligations which bear heavily on all those who are strong in faith and knowledge.

Our progress, as the report attests, has been remarkable. Industry has learned the lesson other nations, the universities, and science itself have taught. Research is one of those dynamic forces by means of which human intelligence keeps pace with the inevitable evolutionary processes characteristic of the universe. It is the most hopeful means by which adaptation to environment and change can be effected. Fortunately, its spirit and method are well known to engineers as well as scientists. But engineers must take the broad view of it and help others in their understanding of its virtues.

After Defense—What?

FOR many months in these pages attention has been directed to problems of "post-defense planning," as the National Resources Planning Board calls it in a recently released pamphlet, "After Defense—What?"

If awareness of the existence of a problem were guarantee of its solution, little fear would be entertained of an orderly and proper tapering off of defense projects, an easy absorption of defense workers into profitable peacetime pursuits, a painless liquidation of defense contracts, and a rapid rehabilitation of the peoples and economies of war-devastated nations. Little imagination is needed to form even the crudest estimate of the size and difficulty of the task ahead, but an amazing degree of faith in men and their institutions is necessary to warrant hope of success, and superior intelligence and statesmanship will be required to achieve that success. Yet without that imagination, that faith, and that intelligence we face the alternative of a period of misery and chaos the like of which has not been experienced in civilized times.

What the National Resources Planning Board sets forth in its pamphlet is the merest outline of the problem and the objectives as this board sees them. It estimates, for example, that by 1944 all of the 60 million possible workers will be employed, 27 million in military service and defense industries and the remainder in other work. It estimates a national income of 105 billions, derived from 129.6 billions of man-hours of work, and it poses the problem of maintaining this income by the reabsorption most of the 27 million into peacetime activities without the economic and social dislocations which have inevitably followed destructive wars.

"The real problems of war," says the pamphlet, "never arise until after a war is over. When this war is won we can lose everything we are arming to defend, if, in the transition to peace, we slip back to a low national income with its inevitable unemployment, suffering, chaos, and loss of freedom. To discover ways and to work out the plans for shifting from full employment for defense to full employment for peace is a matter of outstanding public concern."

None can deny the truth of this statement or fail to realize the gravity of the challenge. On the shoulders of engineers will fall a large portion of the burden of meeting the challenge with success. Were it a problem of production only, no doubt would exist of the ability of engineers to accomplish the task. But it is not so simple. Something more is needed.

Back of every great forward surge of the human race have been motivating forces more powerful than the natural obstacles to progress that have been overcome. In the darkness of the world's troubles new motivating forces must be gathering strength and finding expression. For generations the civilized world has held in its hands the powerful implement of science. It has seemed to many that such objectives of peaceful abundance as the National Resources Planning Board defines may be attained by the proper uses of science. But how frequently have the fruits of progress turned bitter in men's mouths and led them to wish that progress itself might have been halted at some happy moment wistfully recaptured in memory, when the onward surge of life has brought painful evidence of the dynamic quality of life itself, the revolutionary process of restless change, and the saying, "I came not to send peace but the sword."

For the comfortable flesh of man's well being must be strengthened by a tough moral fiber, held erect by an articulated structure of active purpose, and quickened by intelligence in harmony with its destiny. Science and engineering may alleviate physical suffering, enhance security, and multiply material things, and still leave the world barren of satisfaction and a sense of purpose and values. Science leads men to an appreciation of the significance of change. It may lead them also to add to a critical appraisal of the value of security and the material fruits of science a discovery of motivating forces whose proper use affords a fundamental solution to the confusing conundrum "After Defense—What?"

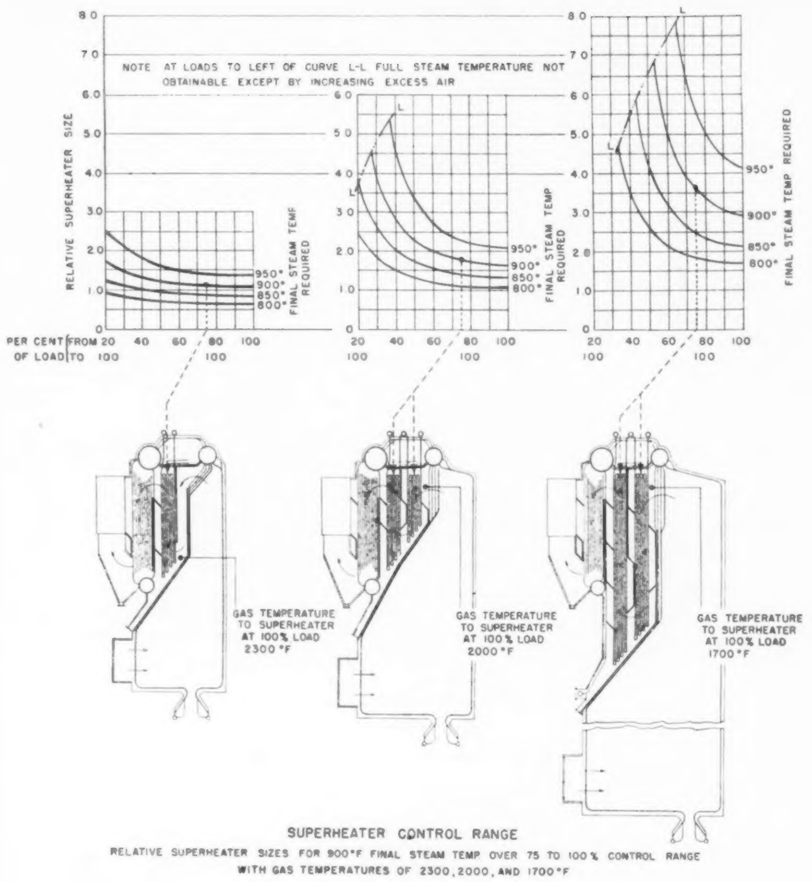

FIG. 1 EFFECT OF GAS TEMPERATURE AND CONTROL RANGE ON SUPERHEATER SIZE

(Pressure 1325 psi at superheater outlet. Conventional wet-bottom pulverized-coal-fired unit.)

SUPERHEAT CONTROL

By MARTIN FRISCH

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THE desirability of providing some means for controlling the temperature of superheated steam from a boiler has been appreciated for many years. However, only during the last few years has the practice become general.

As yet few engineers realize the effect of superheat control on the design of the steam generator, or appreciate the limitations of conventional boiler designs when superheat control is desired over a wide load range. Requirements which may be economically met in one design, under one set of conditions, may be entirely impossible of satisfaction in the same type of design, if the conditions are altered slightly.

It is proposed in this paper to outline generally the most important factors affecting superheat control and to describe some of the means now used for this purpose with their relative advantages and disadvantages. Since superheat-control problems at high steam temperatures have accentuated effects tending toward superheater deterioration, it is also proposed to discuss factors affecting superheater life and reliability.

The types of control to be discussed are those employing the following:

1 By-pass and damper.
2 Desuperheater; evaporative type.
3 Desuperheater; feedwater-heating type.
4 Condenser humidifier.
5 Combination superheater; conventional.
6 Combination superheater; separately fired type.

When generating steam at high pressure and temperature with slag-forming fuels and a convection superheater, precise steam-temperature control over a wide load range is only possible by compromises in design which impair the reliability of the steam generator as a whole. The size of a convection superheater depends, among other things, upon the minimum load at which the full specified temperature is required, the gas temperature, rate and type of gas flow available at the superheater, and the feedwater temperature.

If the amount of furnace cooling surface installed ahead of the superheater is large enough to reduce the furnace gas exit temperature sufficiently to freeze all entrained ash particles before reaching the superheater, and if the superheater tubes are spaced on wide centers to prevent bridging, the required final steam temperature may not be attainable over the desired load range with any superheater of practical size. As the gas temperature

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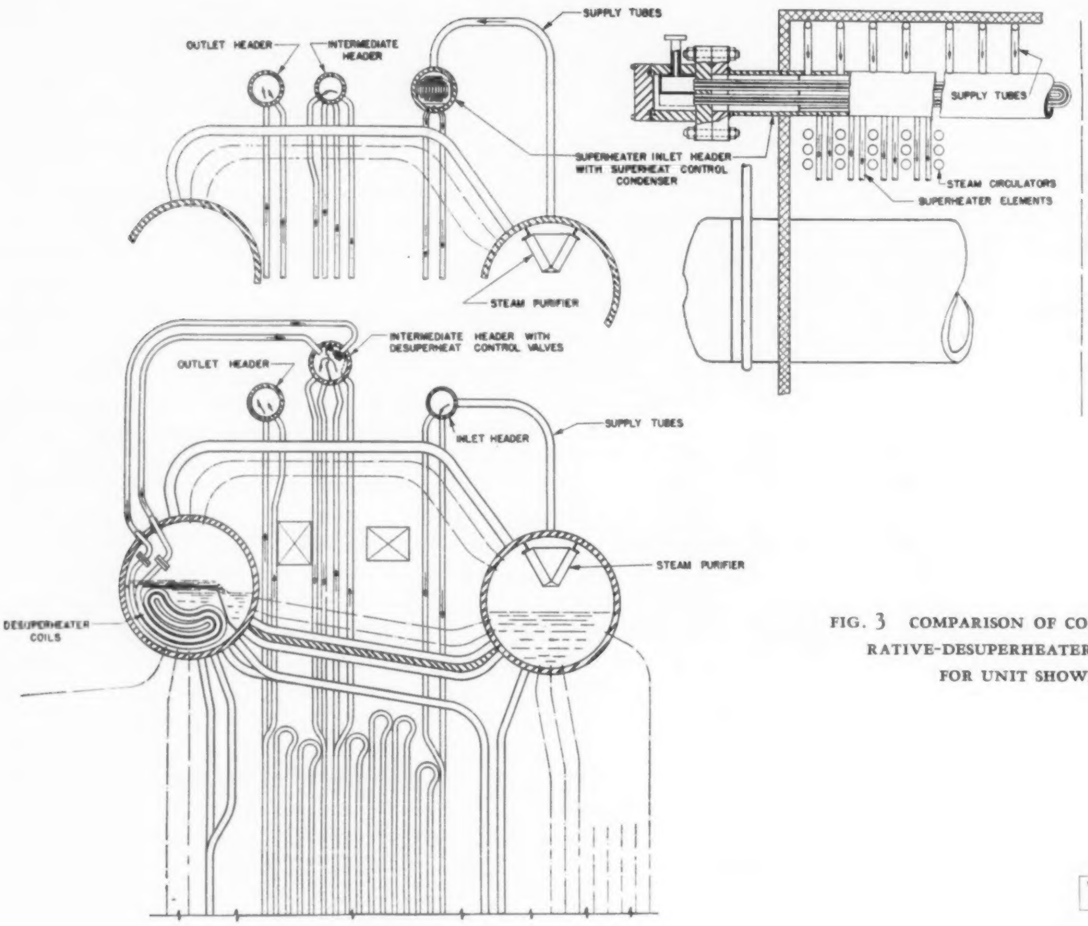

FIG. 3 COMPARISON OF CONDENSER- AND EVAPORATIVE-DESUPERHEATER-CONTROL SYSTEMS FOR UNIT SHOWN IN FIG. 2

to the superheater decreases, and the load range over which it is desired to maintain a given steam temperature constant increases, the size of the superheater increases rapidly. This is illustrated in Fig. 1 based on a study of superheaters for operation at 1325 psi from which it may be deduced, for example, that if a final steam temperature of 900 F is to be maintained constant from three quarters to full load, the superheater sizes will vary approximately as 1.1 to 1.75 to 3.65 as the superheater gas-inlet temperature at full load changes from 2300 to 2000 to 1700 F, respectively, superheaters for each condition having the same spacing, gas-mass velocity, and feedwater temperature. Actual surfaces for 300,000 lb per hr would be approximately 3770, 6000, and 12,500 sq ft, respectively. The three diagrams of Fig. 1 illustrate to scale relative proportions of the furnaces and superheaters for these three conditions. Obviously, the furnace as well as the superheater shown on the right-hand diagram are impractically large.

If with a full-load superheater-inlet gas temperature of 2000 F it is desired to maintain a final steam temperature of 900 F constant from one third, two thirds, and full loads, respectively, the superheaters will vary in size as 3.5 to 1.85 to 1.6. Actual surfaces would be approximately 12,000, 6350, and 5500 sq ft, respectively.

The highest gas temperature to the superheater which may be tolerated depends upon the slagging characteristics of the fuel fired. Generally, it is possible to design a unit with an all-convection superheater of reasonable size only by accepting a higher furnace-exit temperature than the desire for maximum reliability and freedom from slagging would indicate to be proper, or by reducing the steam-temperature-control range.

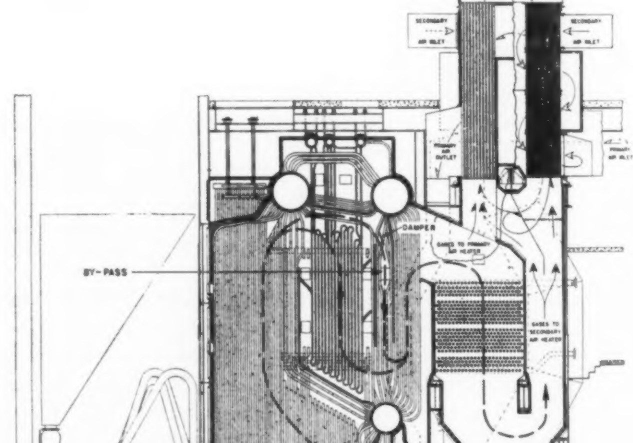

FIG. 2 GAS BY-PASS CONTROL APPLIED TO 550,000-LB UNIT
(Working pressure 820 psi, final steam temperature 900 F, from 66 to 100 per cent load.)

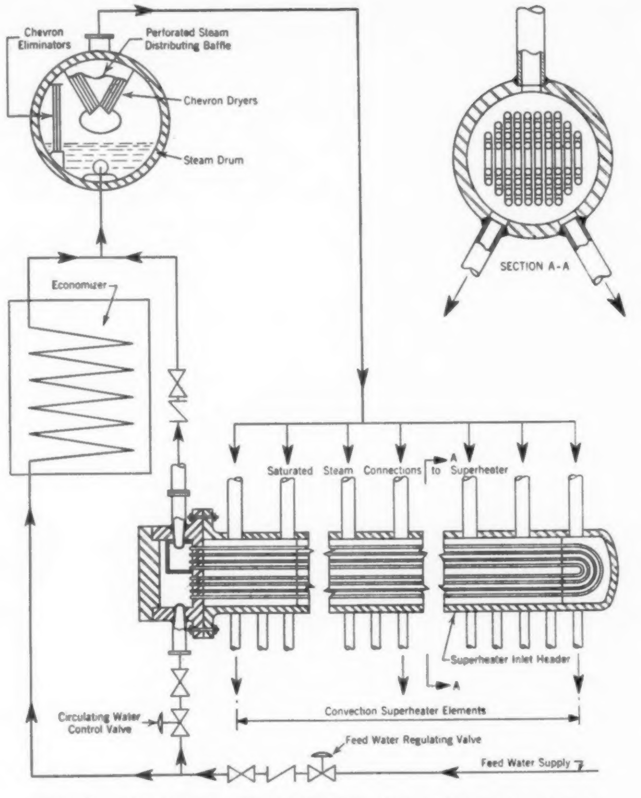

FIG. 4 CONDENSER STEAM-TEMPERATURE-CONTROL SYSTEM

Since the control range obtainable depends upon the furnace design and the size of the superheater, the method of control affects only the ease with which the steam temperature may be regulated to suit turbine requirements. If they are of adequate size, controls of the gas by-pass, desuperheater, or condenser types will be approximately of equal effectiveness, although they will not respond with equal rapidity.

METHODS OF CONTROLLING SUPERHEAT

By-Pass Control. The gas by-pass type of control is illustrated in Fig. 2, as applied to a 550,000-lb per hr unit, designed to deliver steam at 820 psi, and 900 F final steam temperature over a load range of 66 to 100 per cent with a feedwater temperature of 300 F at full load. The final steam temperature is maintained at the desired value by regulating the amount of gas flowing over the superheater by means of a by-pass damper.

Fig. 3 shows the application of controls of the desuperheater and condenser types to the same boiler.

Desuperheater-Evaporator Control. In the desuperheater type of control the final steam temperature is regulated by varying the temperature of the steam at an intermediate point in the superheater by desuperheating all or part of the steam in desuperheating coils in one of the boiler drums or in a separate pressure vessel. The steam to be desuperheated is diverted to the coils, and after desuperheating is returned and mixed with the undesuperheated steam before passing through the rest of the superheater. Control is by means of a valve within the intermediate header as shown, or by using external valves and piping to regulate the desuperheating and remixing. The steam, which flows at high velocity through the desuperheating coils, gives up heat to the boiler water which surrounds the coils, causing it to boil. Sometimes, when the desuperheater coils are located in a separate pressure vessel, the desired amount of desuperheating is regulated by varying the amount of immersion of the coils.

Desuperheater-Feedwater-Heater Control. Another method of controlling by desuperheating is to pass part of the feedwater through coils installed within the intermediate header of the superheater, or by spraying of feedwater over coils through which the steam is passed, located in a separate vessel.

Condenser Control. The condenser type of regulator operates by controlling the humidity of the steam entering the superheater by condensing part of the steam after complete purification by washing or other adequate means in the boiler. So that the steam is humidified with chemically pure water. This method precludes the possibility of introducing scale-forming solids into the superheater, as in the past with water injection from an outside source. This is accomplished as shown in Fig. 4 by controlling the amount of feedwater flowing through the condenser heat exchanger, located within the superheater inlet header. This method is more rapid than either the gas by-pass or desuperheating methods because it requires less surface for the same control range than desuperheating methods, and the temperature of less metal has to be changed when the steam temperature changes. The control valves, operating as they do on water, are relatively small, compared to the large steam valves required in the desuperheater control system for passing superheated steam with low pressure loss. Hence, the regulating mechanism is simpler and lighter than required for either by-pass or desuperheater types. The condenser method has the further advantage that loss in pressure of the steam flowing over the condenser surface is negligible, as compared with the necessary pressure loss through or over desuperheating surface, if the amount of desuperheating surface is not to be prohibitive.

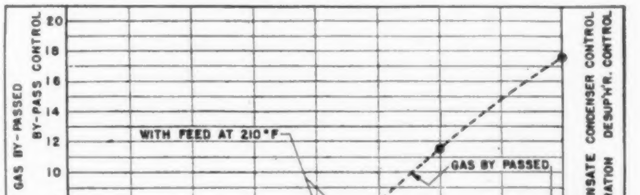

FIG. 5 COMPARISON OF CHARACTERISTICS, BY-PASS, CONDENSER- AND EVAPORATIVE-DESUPERHEATER-CONTROL SYSTEMS FOR UNIT SHOWN IN FIG. 2

The amount of steam condensed for a given range of control in the condenser system is very nearly the same as the amount of water boiled in the evaporator type of desuperheater control.

CHARACTERISTICS OF BY-PASS, DESUPERHEATER, AND CONDENSER CONTROLS COMPARED

Fig. 5 compares the duty of the by-pass, desuperheater, and condenser types of control on the 550,000-lb per hr unit, shown in Fig. 2, in order to maintain a constant steam temperature both with varying load and temperature of feedwater. As the feedwater temperature drops, more fuel has to be burned to generate the same weight of steam per hour, hence the temperature of the gas at the superheater and the final steam temperature both rise. The gas by-pass and damper, as well as the evaporator type of desuperheater, must be sufficiently large to compensate for the effect of decreased feedwater temperature when feedwater heaters are not in service. This may roughly double the capacity of the required by-pass and desuperheater. With controls of the condenser- and nonevaporative-desuperheater types, the reduced feedwater temperature automatically increases the condensing or cooling capacity and compensates to a large degree for the increase in duty due to decrease in feedwater temperature.

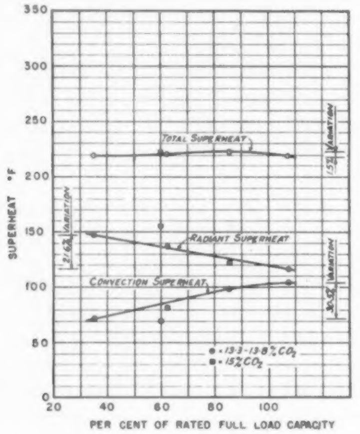

FIG. 6 CHARACTERISTICS OF COMBINATION SUPERHEATER; 110,000-LB PER HR UNIT

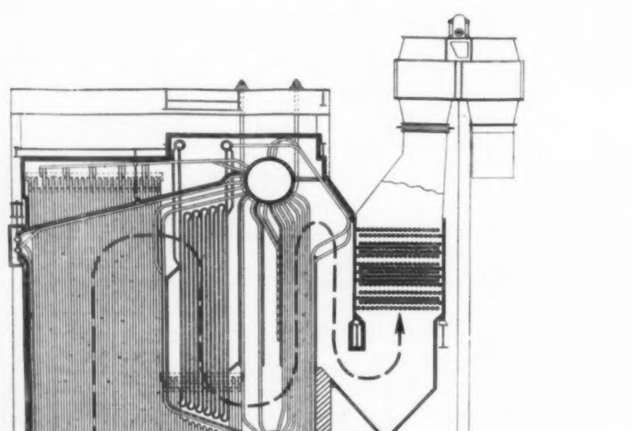

FIG. 7 TYPICAL COMBINATION SUPERHEATER APPLIED TO SINGLE-FURNACE BOILER

(Steam output 300,000 lb per hr at 1325 psi 960 F final steam temperature, from 30 to 100 per cent load.)

The comparative surfaces required are 130 sq ft of condensing-control surface, 300 sq ft of evaporative-desuperheater surface, and 1400 sq ft of nonevaporative feedwater-desuperheating surface. The corresponding pressure losses on the steam side of the condenser- and nonevaporative-desuperheater types are negligible, being of the order of 1 or 2 lb whereas on the evaporative-desuperheater type it is of the order of 30 or 40 psi. The nonevaporative desuperheater requires so much surface because the steam velocity over the surface cannot be conveniently made high if the surface is located in the intermediate superheater header. Hence, the over-all heat-transfer rate is only about 40 to 50 as compared with 300 in the evaporative desuperheater and 1000 in the condenser. On the other hand, the pressure loss is low and compares favorably with that obtained in the condenser type.

As may be seen in Fig. 5, it takes a very small amount of condensation or evaporation to give the desired control, namely, $2^1/_2$ per cent with normal feedwater temperature, and 6 per cent when the high-pressure heater is out and the feedwater temperature is low. The gas by-pass must handle $7^1/_2$ to $17^1/_2$ per cent of the total gas under the corresponding feedwater conditions.

COMBINATION SUPERHEATERS

Experience over the years has demonstrated that high steam temperatures at high pressures over wide load ranges with furnace-exit temperatures low enough to preclude slagging of the superheater may be obtained by the use of combination radiant-and-convection superheaters. It is well known that as the load increases the steam temperature from a radiant superheater falls, while that from a convection superheater rises. By proportion-

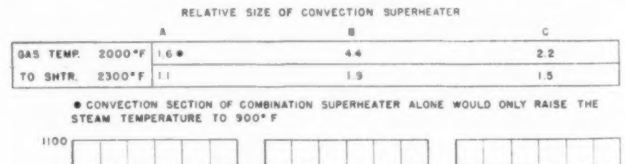

FIG. 8 COMPARISON OF COMBINATION- AND CONVECTION-SUPERHEATER CHARACTERISTICS FOR UNIT SHOWN IN FIG. 7

ing the surfaces properly, it is possible to balance these complementary characteristics of the two types of superheaters so as to obtain a final steam temperature which remains practically constant over the entire load range. The deviation from constancy is so small that but minor correction is required. This is illustrated in Fig. 6 showing actual results on a combination superheater for an installation of moderate pressure and capacity. Control equipment in such installations is required only to correct for changes in feedwater temperatures from the normal. Changes in CO_2, as may be seen in Fig. 6, affect the final steam temperature of the combination but slightly, because though individually the effects of radiant and convection sections are large, the effects are opposite and cancel each other.

A number of high-pressure high-temperature installations utilizing combination superheaters in conventional single-furnace as well as in twin-furnace units has been made in recent years based on satisfactory experience over long periods in large and small installations. Typical of the many conventional single-furnace-type installations with combination superheaters recently carried through is the 300,000-lb per hr, 1550-psi, 960-F unit for an eastern public utility shown in Fig. 7. Fig. 8 compares the superheat characteristics of this unit with those which might have been obtainable by the substitution of an all-convection superheater, either with or without control. It is interesting to note that with a full load gas temperature of 2000 F entering the superheater control from below 30 per cent to full load is obtainable with the combination superheater with one fourth less convection surface than would be required with an all-convection superheater having no control range at all and with about just over one third the surface required for a control range of 45 to 100 per cent with an all-convection superheater. Each square foot of exposed radiant surface replaces approximately 6 times that much convection surface.

TWIN-FURNACE BOILERS WITH SEPARATELY FIRED SUPERHEATERS

For yet wider control ranges, and certain freedom from slagging and for precise steam-temperature control, irrespective of feedwater temperature, fuel, or excess air, twin-furnace boilers consisting of a separately fired superheater furnace in parallel with an otherwise similar boiler furnace have found application in the last 5 years. As already described from time to time,[1] they have been used in situations where rigid steam-temperature-control requirements had to be met under all conditions with good or bad fuel. Some of these units, ranging in size from 40,000 to 750,000 lb per hr, have been in marine and stationary service since 1936. Numerous additional marine units of this type for capacities of over 100,000 lb per hr and seven large stationary installations for capacities of 450,000 to 500,000 lb per hr with final steam temperatures of 910 to 950 F, maintainable over load ranges of about 6 to 1, are now under construction. The stationary units, of which Fig. 9 is typical, were designed with much lower gas furnace-exit temperatures than would be practical with conventional single-furnace units having convection superheaters for the same range of steam-temperature control.

The superheater side consists of a completely water-cooled furnace except for the inside wall which is completely covered by the radiant section of a combination superheater. The radiant-convection sections of the superheater form integral elements requiring no interconnecting piping. Alternate tubes of the radiant section are connected to the steam drum at the top and take saturated steam from it after complete purification within the drum. The steam flows downward to a return header at the bottom, then upward through the adjacent radiant-superheater tubes, their integral convection elements, and to the outlet header. The radiant and convection heat-absorbing surfaces are so proportioned as to produce a final steam temperature which deviates insignificantly from the desired value over the entire load range. The small deviation is corrected by adjusting the rate of firing of the superheater furnace. The final steam temperature depends only upon the steam flow through the superheater and the firing rate in the superheater furnace. Hence, the final steam temperature may be altered at will by firing more or less fuel in this furnace. Fuel is fired

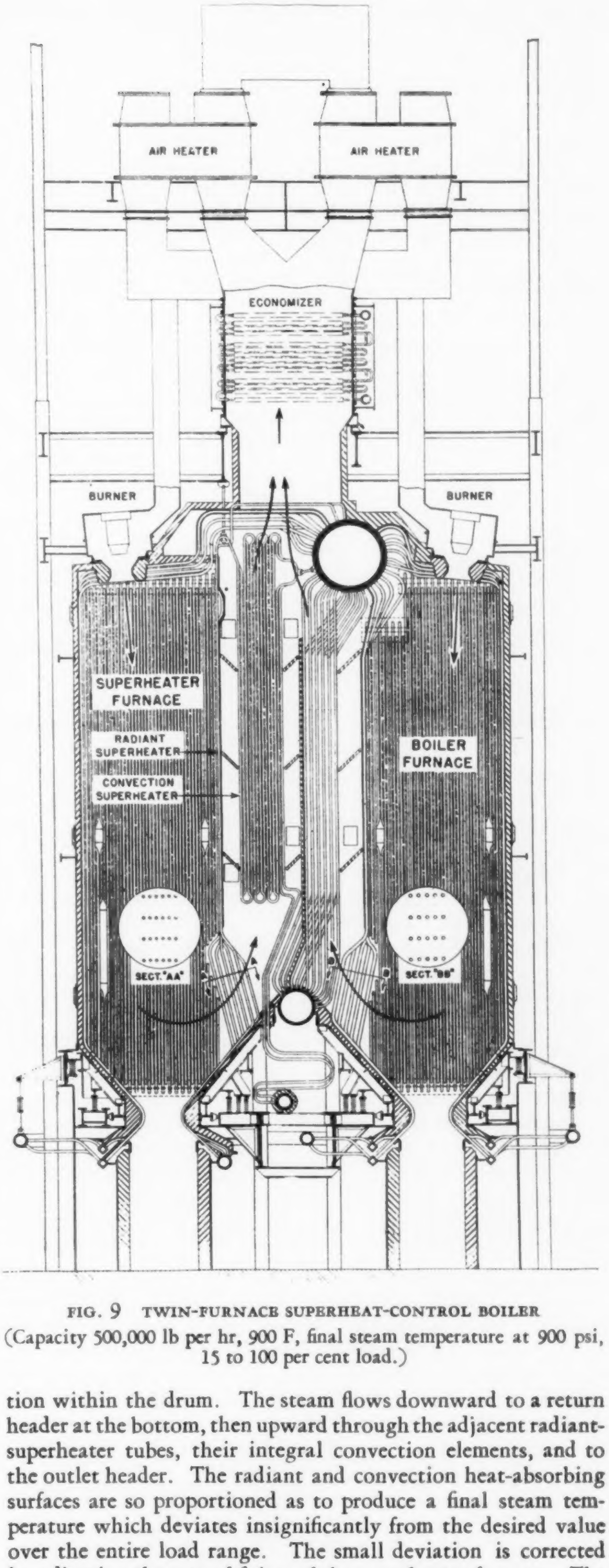

FIG. 9 TWIN-FURNACE SUPERHEAT-CONTROL BOILER
(Capacity 500,000 lb per hr, 900 F, final steam temperature at 900 psi, 15 to 100 per cent load.)

[1] "Some Particulars of Design and Operation of Twin-Furnace Boilers," by John Blizard and A. C. Foster, presented at the Annual Meeting, New York, N. Y., December 2–6, 1940, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

at the top with short-flame burners. Gases pass downward and out of the furnace through an ash screen near the bottom into the convection superheater. After passing through the superheater they flow upward into the economizer. Saturated steam alone may be produced, if desired, by firing the boiler furnace and not firing the superheater furnace.

The boiler furnace is like the superheater furnace, except that the inside wall is a waterwall and the gases, after passing out of the furnace through the ash screen, flow upward through steam-generating surface instead of the superheating surface. The superheater side and the boiler side are separated by a vertical baffle which guides the gases from each side into the

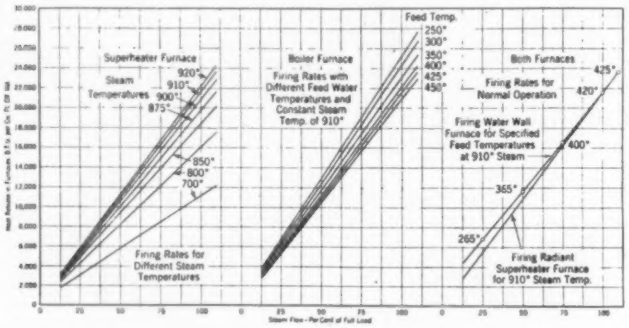

FIG. 10 CHARACTERISTICS OF TWIN-FURNACE SUPERHEAT-CONTROL UNIT

economizer without mixing before reaching the economizer inlet. The boiler side is generally so proportioned that the gas temperatures leaving boiler and convection superheater are nearly the same.

Should the feedwater temperature increase, the firing rate of the boiler only is increased. Fig. 10 shows, on the right, the comparative firing rates of the two furnaces for a constant steam temperature from 15 to 100 per cent load with specified feed temperatures. If the feedwater changes from that specified, the firing rate of the superheater furnace need not be changed as long as the steam temperature required remains unchanged, but the firing rate of the boiler furnace must be changed as indicated at the center of Fig. 10.

If it is desired to change the steam temperature, the firing rate of the superheater furnace is changed as indicated at the left of Fig. 10.

The manual or automatic control of a twin-furnace boiler of this type is very simple. Each pulverizer is provided with two exhausters, having independent output controls. One exhauster supplies fuel to burners in the superheater furnace, the other to burners in the boiler furnace. The required steam output is maintained by controlling the total fuel to the two furnaces, increasing or decreasing simultaneously the output of the two exhausters as required. If the steam temperature deviates from that desired, the required correction is made by diverting more or less fuel to the superheater furnace as the steam temperature falls or rises. As may be seen from the right-hand chart in Fig. 10, the amount of fuel to each furnace is the same at full load. The deviation from equality as the load decreases is small and very little control is required. Control may be manual or automatic.

Twin-furnace units of this type have the advantage that in a given furnace volume 20 to 50 per cent more furnace-wall cooling surface may be installed, hence a lower furnace-exit temperature may be readily maintained than in conventional units which have the same total furnace volume.

PROTECTION OF SUPERHEATERS

The life of a superheater, whether of the all-convection, radiant or combination type, assuming a steam supply of utmost purity, depends upon the care used in its design and operation.

Superheater tubes may be damaged in service because of inadequate steam flow through them, as a result of the superheater being designed for a pressure drop that is too low. This often results in poor steam distribution between the elements, especially at low output rates. Local high-temperature gas concentrations in portions of the superheater, due to poor firing conditions in the furnace or partial slagging of the superheater, may cause excessively high localized metal temperatures.

Fig. 11 summarizes temperature measurements made on the outlet ends of elements of a large convection superheater of the pendant type with good as well as bad gas and steam distribution. This superheater installed in a 750,000-lb per hr unit delivers steam at 1325 psi and 925 F. The elements in the hot section of the superheater are 4 to 6 chrome stabilized with titanium. The limiting metal temperature for 1 per cent creep in 100,000 hr is 1075 F. The steam flow per element in this installation is unusually high. Nevertheless, the steam leaving some of the elements, when firing conditions and gas distribution were poor, approached the creep-limit temperature, indicating that metal temperatures in these particular elements probably exceeded the creep limit. With good firing conditions temperature variations from the mean were reasonably low with a comfortable margin below the creep limit. Experience indicates that past tendencies limiting superheater pressure drop to low values were unwise. Experienced operators now readily accept superheater pressure drops of 75 to 100 psi and even

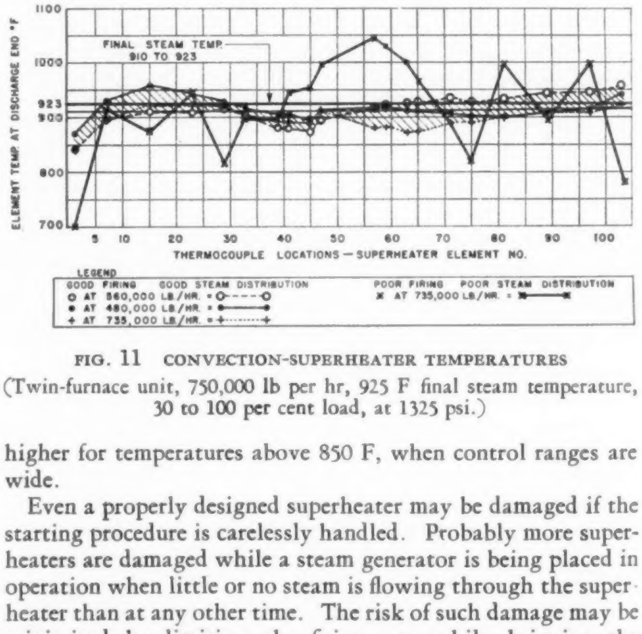

FIG. 11 CONVECTION-SUPERHEATER TEMPERATURES

(Twin-furnace unit, 750,000 lb per hr, 925 F final steam temperature, 30 to 100 per cent load, at 1325 psi.)

higher for temperatures above 850 F, when control ranges are wide.

Even a properly designed superheater may be damaged if the starting procedure is carelessly handled. Probably more superheaters are damaged while a steam generator is being placed in operation when little or no steam is flowing through the superheater than at any other time. The risk of such damage may be minimized by limiting the firing rate while bringing the boiler up to pressure so that the gas temperature at the superheater does not exceed 1000 F. This temperature for any particular unit depends primarily upon the firing rate. The time required to bring the boiler up to pressure is equal to the heat capacity or "water equivalent" of the unit at pressure minus its water equivalent at the start divided by the rate of heat inflow to the structure which is proportional to the firing rate.

When auxiliary oil or gas burners are used for bringing a boiler up to pressure, the number and capacity of the burners may be so selected that the burners may be lit and kept firing continuously at the required rate until the unit is up to pressure. However, if the unit is "direct-fired" with pulverized coal, the minimum stable pulverizer and burner capacity may

exceed the firing rate permissible if the limiting gas temperature at the superheater is not to be exceeded. The unit must then be brought up to pressure more carefully by firing intermittently, as shown in Fig. 12, which is typical of the unit shown in Fig. 2. The length of the on and off periods is so selected that the proper total time as previously defined is taken to bring the unit up to pressure. Temperature equalization takes place during off periods throughout the unit, minimizing the effects of possible inequalities in heat absorption of adjacent parts and resultant damaging thermal stresses while circulation is being established uniformly in waterwalls and steam-generating tubes. If adequate vent and drain valves are provided and used on the superheater some steam flow through the elements will be established as soon as the steam pressure in the unit exceeds atmospheric pressure. This flow progressively increases as the pressure increases.

Sometimes the vents are connected to a condenser which not only accelerates the steam flow through the superheater, thus increasing the protection, but serves as a means of preventing condensate loss. When the condenser type of superheat control is used, the condenser provides a means of keeping the superheater flooded with pure condensate during the firing-up process, assuring certain protection for the superheater. Flow of condensate through the superheater is controlled by means of a vent valve on the outlet header.

Radiant superheaters in conventional single-furnace units are favored when starting by bringing the unit up to pressure

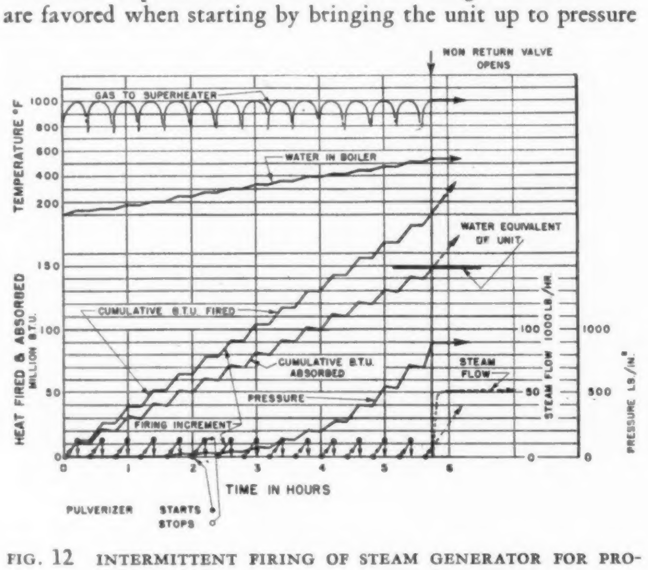

FIG. 12 INTERMITTENT FIRING OF STEAM GENERATOR FOR PROTECTION OF SUPERHEATER WHILE STARTING

with the burners most distant from the radiant superheater. With adequate venting facilities, and particularly if the condenser type of control is used and the radiant superheater can be kept flooded with condensate adequate, protection may be obtained until the unit is up to pressure. In twin-furnace boilers superheaters cannot be damaged when starting because no fuel is fired in the superheater furnace until the unit is up to pressure and steam is flowing through the superheater.

Properly designed radiant superheaters are as safe from damage in normal operation as properly designed convection superheaters. As a rule, maximum metal temperatures in radiant-superheater elements can be kept at a safer low level than in outlet legs of most high-temperature convection superheaters because it is customary to use the radiant section as the primary superheating stage through which the coldest steam is passed. With a reasonably high pressure drop and adequate steam flow per element over the operating-load range, it is possible to keep metal temperatures well below the creep-limit temperature. This is quite important, because it is no more possible to have the rate of heat absorption by radiation uniform over all the radiant heat-absorbing surface in a furnace than it is possible to have each square foot of convection superheater absorb heat at exactly the same rate. Therefore, it is the maximum, not the mean, metal temperature which determines the safety of any heat-absorbing surface.

Fig. 13 shows how the element outlet temperature varies along a radiant superheater of the 750,000-lb per hr high-pressure twin-furnace unit already referred to. Corresponding furnace gas-temperature measurements serve as an index to these variations. The steam flow through the elements of this

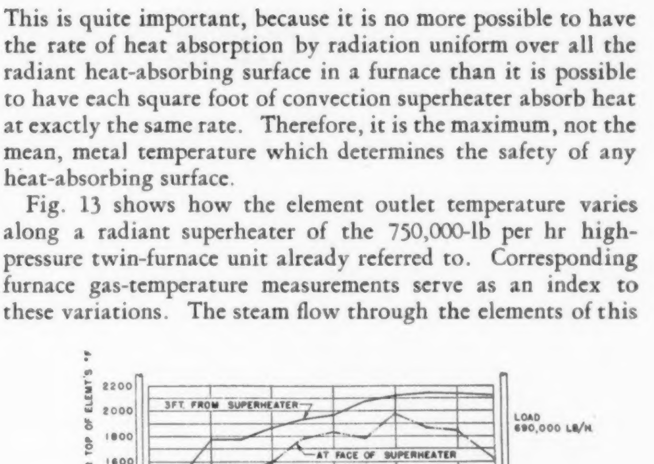

FIG. 13 RADIANT-SUPERHEATER TEMPERATURES

(Twin-furnace unit, 750,000 lb per hr, 925 F final steam temperature at 1325 psi, 30 to 100 per cent load.)

superheater is sufficiently high so that the maximum metal temperature, even in the hottest elements, is well below the creep-limit temperature at all loads. These elements are made of stabilized 4 to 6 chrome.

SUMMARY

A high steam temperature may be maintained constant over a wide load range with a convection superheater of reasonable size only by tolerating a high furnace gas-exit temperature.

If high furnace-exit temperatures cannot be tolerated because slag-forming fuels are to be burned, a reduction in the control range of the convection superheater must be accepted.

If neither a high furnace-exit temperature nor a limited control range can be tolerated, it is advisable to use a combination radiant-and-convection superheater, preferably in a twin-furnace type of unit with the combination superheater separately fired.

For regulating steam-temperature controls of the by-pass, desuperheater or condenser types may be used for conventional superheater installations. Units of the twin-furnace type with separately fired superheaters are controlled by differential firing and such units can be designed for lower furnace-exit temperatures and wider control ranges than conventional units.

Damage to superheaters in operation and during starting up may be avoided by proper care in equalizing gas and steam distribution to the superheater and by proper manipulation of the firing equipment and superheater when starting.

DEFENSE TRAINING

As It Presents Itself at a Government Arsenal

By N. F. RAMSEY

BRIGADIER GENERAL, U.S.A., COMMANDING, ROCK ISLAND ARSENAL, ROCK ISLAND, ILL.

TO MEET the enormous demands of the Ordnance Department for inspection and operating personnel, it has been necessary to inaugurate comprehensive training plans at all the manufacturing arsenals. Each such arsenal has its individual problems. At Springfield Armory and Frankford Arsenal, the problems are mainly those of mass production of relatively few items. With us at Rock Island Arsenal the problems are more varied for we are engaged in the manufacture of machine guns, tanks, high-speed modern carriages, and recoil mechanisms for antitank guns, and for light, medium, and heavy field artillery. With such diversified activities it is imperative to have a large number of all-round mechanics. At the moment, as you know, they are scarcer than the proverbial hen's teeth.

Our training of personnel falls into two categories. First, the personnel trained at the Arsenal for service at other ordnance plants or establishments. These include administrative personnel, inspectors, armament machinists, and automotive mechanics. In the second group are the men who are being trained for work at the Arsenal to meet the constantly increasing demand for skilled labor.

ADMINISTRATIVE PERSONNEL

Of those trained to serve at other ordnance plants, the administrative personnel has been appointed from eligibles certified from Civil Service lists of administrative technicians and most of them have had some college education. Our training of these men consists mainly in familiarizing them with Arsenal administrative procedure, fiscal operation, procurement procedure, property control, civilian personnel procedure, planning, and mail and record activities. Their instruction consists of lectures, reading, and actual work in each of the administrative divisions of the Arsenal. This is a two months' course and ten men have completed their instruction and have been assigned to new ordnance plants. Another group of 90 men is now being organized to meet the demands of new plants in process of being constructed. Of course, this training will cease as the new plants are completed.

INSPECTORS

The training of ordnance inspectors, however, gives promise of being more prolonged. These men come to us from various ordnance procurement districts. We are conducting two concurrent training courses for inspectors at the present time. The first includes basic instruction in inspection problems while the second combines more advanced and comprehensive training with greater opportunity for actual experience in final inspection procedure.

Six groups of inspectors with a total of 270 men have been trained in the basic course and a seventh group of 50 men is now being enrolled.

During the first half of the six weeks' basic course, lectures with shop and laboratory instruction are provided to acquaint the trainees with precision instruments and their use, with materials encountered in ordnance manufacture, and with the testing, heat-treatment, and fabrication of metals. The second three-week period is devoted to general inspection procedure with the final inspection of one of the following classes of equipment: mobile artillery carriages, automotive equipment, small arms, recoil mechanisms, or small arms equipment.

All examination is given to all men shortly after they report for the basic course. This is an exploratory operation to determine their respective abilities in mathematics, in shop practice, in blueprint reading, and in the use of precision instruments. Results have usually disclosed *deficiencies* in one or more of these subjects.

Deficiencies in mathematics have been particularly noticeable among those enrolled in the basic course. Demands from these embryo inspectors for assistance in this subject were so urgent that arrangements were made with a local high school in the neighboring city of Davenport, Iowa, to provide the teaching facilities required. The instruction is given two nights per week, for two hours each, during four weeks of the course. Attendance is optional, but interest was so great that four instructors were necessary for the last group of 54 men. The trainees are divided into sections in accordance with their grades on the preliminary examination so as to enable men with superior mathematical training to proceed more rapidly.

The supplementary training in blueprint reading consists of a two-hour instruction period each Saturday morning at which attendance is voluntary. However, it is well attended as special series of exercises in drawing and blueprint reading must be completed by each trainee.

The chief of the gage laboratory at the Arsenal provides supplementary training on precision instruments each Saturday afternoon during the course to those who desire it. Recently, there has been made available to these inspector trainees, a small supply of precision instruments for practice in their use. These instruments are located at the classroom and are issued to the men at odd hours, usually before and after the daily classes.

The scheduled lectures are presented by keymen of the Arsenal who are specialists in their respective fields. Laboratory exercises, shop work, and training in final inspection are administered by the Arsenal employees normally engaged in such work. Oral quizzes and reviews and written preliminary and final examinations are conducted by the officer in charge of the school.

As to the advanced course for inspectors, only those men are eligible who give promise of developing into leaders in their field. They must not only have completed the basic course at some Arsenal but must have had some experience in ordnance inspection work. Two groups with a total of fifteen inspectors have just finished this advanced course at Rock Island Arsenal and a third group is to be started shortly. It is a ten weeks' course and is planned to afford the maximum amount of training in actual final inspection work. One week is devoted to study and use of gages in the gage laboratory. Two weeks are spent in the chemical and physical laboratory to learn the methods used there to inspect materials and to familiarize the

Contributed by the Committee on Education and Training for the Industries, and presented at the Semi-Annual Meeting, Kansas City, Mo., June 16–19, 1941, of The American Society of Mechanical Engineers.

men with such procedure. The last seven weeks are occupied in gaining experience in the final inspection of the particular equipment which each man is to inspect in his particular district. This experience is acquired very practically by actually making the final inspection of matériel produced at the Arsenal.

Efforts are made to develop leadership in the advanced group by means of daily conferences. At the beginning of the course, the officer in charge leads a discussion each day on some topic related to the training program. After several days of this procedure, each trainee is assigned a subject. This leads to the development of daily discussions which are handled by the inspectors themselves. This training should aid the men in dealing with other inspectors who later may come under their supervision.

Visual aids are employed in these training courses to facilitate the understanding of material presented in lectures. A balopticon with slide attachment and motion-picture projector equipped to show sound films are permanent equipment.

The training courses, which have been described, are as nearly complete as the amount of available time and personnel will permit. Revisions are made from time to time in the content of the courses as the need arises, for we are making an all-out effort to train these men to become efficient ordnance inspectors.

ARMAMENT MACHINISTS

Then there are the armament machinists. In order to maintain the modern ordnance material in service, it is essential that each large camp, post, or training center have on its staff qualified and experienced machinists. In ordinary times the demand for such men is not great but in the present emergency with the large increases in the army in the field and many far-flung activities, there has been a heavy demand for armament machinists.

Prior to the present emergency, men needed for this purpose by the various field agencies of the Army were obtained from some one of the manufacturing arsenals. These men were employees who had been in the Ordnance service for several years with wide experience in the various shops of the Arsenal. They were suitable for assignment without additional training. However, even in those days the number of such men that could be spared from various departments of the manufacturing arsenals was limited.

Two groups of armament machinists, a total of 36 men, have recently been trained at the Arsenal and a third group of 53 men will complete their course of instruction this month. These men are all machinists or toolmakers by trade when they are selected for this specialized training in ordnance matériel.

As a result of experience in training men for this duty, a separate school has been established and competent instructors assigned. The course of instruction includes two weeks' training in small arms, three weeks on fire-control instruments, five weeks on automotive equipment (tanks), and six weeks on artillery, a total of 16 weeks. This course of instruction does not include classroom lectures nor do we require any home work.

Our aim in this instruction is to fully acquaint the trainee with all the details of assembly of the various pieces of combat equipment; the type of work necessary for the accuracy involved; and an acquaintance with the use of the parts list, which is very necessary if a man is to order the replacement parts of a damaged piece of equipment. The fundamentals of the design are also gone over in detail to give the trainee a background of the requirements and limitations of the equipment.

We believe this practical type of training is easier to teach and more readily picked up by the trainees than training which would be conducted in a classroom, either by text reference or by lectures. Many of the men who are taking this training have been out of school several years, and it is difficult for them to readjust themselves to study from textbooks. It was also felt that the men receiving this practical training would have more confidence in themselves if they were given a chance to become familiar with the various assemblies with which they will be later concerned.

While there is no classroom instruction there are extensive examinations given from time to time, usually as each phase of this practical instruction is concluded, the purpose being to help the trainee coordinate the knowledge he has gained.

A class of 40 armament machinists is to be kept in training at all times.

The only remaining group that we train for service at other stations is the automotive mechanics group.

AUTOMOTIVE MECHANICS

With the large number of automotive combat vehicles, light and medium tanks, scout cars, and personnel carriers soon to be in the hands of troops, there is a definite need for trained automotive mechanics to keep this material in repair and in service. These men have been selected with the same care as the armament machinists from Arsenal employees or from Civil Service registers. At one time or another most of the men had held the position of foreman in a garage. They were given three months' intensive instruction in our shops on the maintenance, assembly, and repair of the ordnance vehicles which they would find in service. They were placed under the direct supervision of an assistant foreman who divided them up into small groups and turned them over to lead men who supervised their detailed instruction.

The men receiving this training, as well as those taking the armament machinists' course were encouraged to keep notes on the data given them and upon their own observation. I am happy to say that so far all the trainees, both armament machinists and automotive mechanics, have been so enthusiastic over their instruction that they have spent many off-hours in comparing notes or discussing problems of mutual interest concerning their training.

Technical manuals, training regulations, and additional standard nomenclature lists are available for reference for these trainees. When possible, War Department films are obtained.

All the automotive mechanics trained so far have been transferred to stations in the field, several to foreign service.

A class of ten automotive mechanics is to be kept in training at all times.

APPRENTICES

So much for the training of personnel for duty at other establishments. Let us now turn to the training of men for work at the Arsenal. In order to meet the constantly increasing demand for skilled labor, three plans are employed at the Arsenal for the training of classified employees in noneducational designations for higher positions. They are (*a*) the apprenticeship plan, (*b*) the "In Service" training plan, and (*c*) the incidental assignment plan.

At the present time the Arsenal has in training 65 apprentice machinists pursuing a well-organized four-year course. The apprentice training system was revived at the Arsenal four and one-half years ago, and the first class of 35 young men completed the four-year course in January, 1941. All of these have remained on duty at the Arsenal as machinists.

The apprentice machinist course is divided roughly into two two-year periods. The first period is spent in the apprentice shop under the immediate supervision of the apprentice-school foreman and his assistant. This shop, which is set aside for the purpose, has a well-rounded line of machine tools and the

training is such that by the end of the two-year period, all apprentices are capable of handling the simpler machine operations and of doing some production work.

During the second period, the apprentices are assigned straight production work, either in the apprentice shop or in the production departments, under a very definitely organized routine, designed to give the apprentice experience on all the common types of machine tools. During this part of the course, some time is also spent in the pattern shop and foundry, in the forge and heat-treat department, and in the laboratory.

During the entire four years of apprenticeship, one afternoon a week is given over to classroom instruction in shop mathematics, drawing, etc., and, in addition, each apprentice agrees to complete a correspondence school course paralleling his work.

The number of machinists apprentices in training is but a small fraction of the number of machinists and toolmakers required, but their value in the Arsenal organization cannot be measured alone by their number. The apprentices were originally selected from a Civil Service register on which there was a great competition for places. As a result, young men of a high type were selected, most of whom had completed their high-school courses. Because of their basic qualifications and thorough training in well-equipped shops and on a great variety of work, graduates of the apprentice school are unusually well-qualified for advancement to executive positions.

IN-SERVICE TRAINING

While we have found that apprenticeship is by far the most effective method of training all-round, highly skilled mechanics, yet in the present emergency, other and more rapid methods of training have had to be utilized to provide personnel qualified to perform more specialized operations. Expansion of various departments of the Arsenal has been accompanied by increasing difficulty in obtaining qualified personnel. During this expansion, experienced men must be trained not only to operate machines but also to take over additional responsibilities as assistant foremen and supervisors. The needed experience, which cannot be obtained through original employment in the numbers required, must be provided through "upgrading" plans in the Arsenal itself.

By "upgrading," I mean the promotion of workers from one designation, to ***another requiring more skill***, in order to make the best possible use of their abilities. At Rock Island Arsenal, jobs fall into a progressive sequence, each requiring a greater degree of skill. For example, we have classified laborers, shop boys, and junior messengers at the bottom of the ladder. Just above them we have helpers, for the various mechanics, then come assemblers, machine operators, turret-lathe operators, mechanics, and supervisors. The employees who show aptitude and are desirous of advancing themselves have opportunities to advance from one designation to another. In this way the Arsenal can make the most effective use of its man power and the men who learn rapidly have an opportunity to advance themselves within their limitations.

This method when followed out for some time permits the better qualified workers to work on jobs requiring the greater skill, leaving the less complicated jobs to the unskilled or semi-skilled employees.

The most comprehensive method of upgrading which has been sanctioned by the Civil Service Commission is known as the "in-service training plan." Employees for in-service training are carefully selected from those having the necessary basic qualifications and who give promise of developing the required skill in the designation for which they are to be trained. The employee selected for in-service training retains his original designation and rate of pay but works at the job for which he is being trained. When he attains the required skill and the length of service or experience required by Civil Service regulations, he is promoted to the new designation.

At the present time we have more than 500 employees receiving in-service training, and since Jan. 1, 1941, have advanced some 350 to higher designations as the result of such training. Thus, laborers have been advanced to machinist helpers, machinist helpers to general machine operators, general machine operators to turret-lathe operators, set-up men, and machinists, machinists to armament machinists, production assistants, and inspectors, and production assistants to assistant foremen.

No provision is made for classroom work as with the apprentices and there is no requirement that men on in-service training do any outside work. However, we have found that many of them avail themselves of correspondence-school courses and night schools.

Training of mechanical draftsmen is conducted in somewhat the same manner as in-service training but is really a combination of the principles of in-service training and of apprenticeship. Here we start with junior messengers who enter the service at $600 per annum and who are assigned to work on the drawing files and as assistants in various ways in the drafting division. Those showing aptitude and who have completed successfully a high-school course or its equivalent in mechanical drawing are advanced to the position of apprentice draftsman at $1260 per annum. The next step is that of junior draftsman at $1400 per annum. It requires from two to three years to advance a junior messenger to the grade of junior draftsman. Further advancement depends upon the ability and the experience of the individual and the character and volume of work available in the drafting division.

INCIDENTAL ASSIGNMENT

Still another method of advancement is afforded through training gained by "incidental assignment." This again is a plan recognized by the Civil Service Commission mainly devised to give credit for experience when an employee may be required to work from time to time on a job other than that pertaining to his specific designation. Unless formally designated to receive in-service training and so reported to the Civil Service Commission, an employee, under the rules, may not be diverted from work pertaining to his designation for more than 25 per cent of the time. If he is so diverted, a record is made of the time spent. When he has received enough total service in the higher position to satisfy Civil Service regulations and providing a vacancy is available, he may be promoted thereto. This scheme, therefore, is not so much a system of training as a means of recognizing experience gained when working at a job other than that for which originally employed. It is a happy solution for the Civil Service employee who is too old to be an apprentice and not sufficiently outstanding to qualify for upgrading through in-service training.

CONCLUSION

In conclusion, I believe one of the bright spots that the lean years of the depression has produced is the increased earnestness shown by many young men to improve their workmanship. At the last examination for apprentices we had 1200 applicants. It is a hopeful sign to witness this diversion of traffic from the overcrowded white-collar class. Once in the service, the man with ambition can march ahead. For the very size and speed of the National Defense program has necessitated a marked emphasis on the upgrading of workers. Never before at the Arsenal has the man who is innately industrious and ambitious had a better chance to advance himself. Not only is opportunity knocking at his door, but he is being encouraged and trained to meet that opportunity.

Problems of INSPECTION *of* NAVAL MATERIAL

By F. L. OLIVER

CAPTAIN, U.S.N. (RETIRED), INSPECTOR OF NAVAL MATERIAL, PITTSBURGH DISTRICT

THE Navy inspection system came into being nearly one hundred and fifty years ago when the attacks on our commerce by French cruisers prompted Congress, in 1794, to authorize the construction of six frigates, two of which, the *Constitution* and the *Constellation*, are still in existence. Naval officers were assigned to the ships in the early stages of their construction ultimately to man them when completed and commissioned, but initially to inspect both workmanship and materials, including the assembly of the equipage, ordnance, naval stores, and accessories.

This system has been carried down to the present day, although numerous developments and amplifications have been made to suit advances in complexity of design and materials involved in the transition from wooden ships, through iron and medium steel, to the ships of today, embodying the latest developments of the metallurgical and mechanical sciences.

Naval inspectors and their assistants occupy positions of great trust and responsibility, representing the Navy Department in all transactions with the contractor after the contract is awarded.

In the inspection and test of naval materials, the Navy Department expects the Naval Inspection Service to safeguard the interests of the Navy at all times in enforcing impartially and strictly the contract specification requirements. No matter how expertly and carefully they may be prepared, specifications lose their value and effectiveness unless the material shipped conforms to their requirements. This necessitates careful inspection before shipment. Thorough, efficient, prompt, and dependable inspections of naval materials are essential to the national defense.

Inspection at the place and time of manufacture is fundamental and necessary in order to detect and correct errors in workmanship and to insure that no unauthorized or inferior materials have been substituted for the specified materials. Frequently the detection of such errors after assembly or after shipment is very difficult, and in many cases impossible, later to become evident only through failure of the material while in service. Such failures usually involve the loss of valuable time and funds, perhaps the service of the vessel, and in some cases endanger the operating personnel.

It has been the Navy's experience that in practically all cases the contracting manufacturers have been most cooperative, and their desire to furnish material which will satisfactorily serve the purpose is most commendable.

A large part of the Navy's success in obtaining suitable material is due to the careful manner in which its specifications for material have been evolved, and it may be of interest to know that when the United States entered the World War in 1917, the Navy was the only department of the government with a completely compiled set of specifications; these specifications were adopted almost in toto by other government agencies.

When it is decided that specifications for a new type of material are necessary, the specification section of the pertinent bureau sets forth what requirements are desired, having in mind the particular use for the material. These requirements usually set forth the physical strengths, the chemical composition, and the processing methods necessary to produce the required finish and homogeneity.

These data are then forwarded to various manufacturers for comment, upon receipt of which, a tentative specification is written which is usually a compromise based on all suggestions and the Department's requirements. This tentative or interim specification is then placed in service and, as the material is manufactured, further criticisms from manufacturers and inspectors are considered.

Subject to these comments, the interim specification is revised and when all points at issue have been settled and the material is found satisfactory in service use, the specification is printed in the form of a leaflet for general distribution.

Complaint is sometimes made by manufacturers that Navy specifications are too rigorous and hard to meet, and are not in keeping with somewhat similar material for commercial uses. These manufacturers fail to realize that salt water is a stern critic, and that material for naval use is in many cases required to withstand much more severe usage than similar commercial material, and that failure of material on shipboard might, if occurring in battle, be catastrophic or, if occurring in normal times, would in many cases be extremely dangerous. Aboard ships serving abroad, replacement might be difficult and expensive, and in some instances impossible.

There have been numerous cases where, because of the rigid requirements of Navy specifications, manufacturers have, in order to meet them, found new and improved methods of production which have been beneficial to both parties.

The Navy Department has divided the United States into 15 inspection districts. Of these the Pittsburgh district is one of the most important, and extends from Buffalo and Rochester in the north, to Altoona in the east, Charleston and Parkersburg, W. Va., on the south, and in general to the Pennsylvania-Ohio line on the west. Within this territory, approximately twenty per cent of all the business placed by the Navy Department is manufactured and inspected. For example, in one recent month, a total of 196,000 tons of material was inspected for the Navy throughout the United States. Of that amount, 38,000 tons, or 19.6 per cent, was inspected by the Pittsburgh district. That same month, the total value of materials and machinery inspected was sixty-three million dollars, of which twelve and a half millions, or 19.7 per cent, was inspected by us.

The inspectors in this district are prepared to undertake almost any type of inspection. We run the gamut from a china dish to a massive armor plate—wire, bolts, complicated electric machinery, lumber, gears, Diesel engines, furniture, ordnance material, machine tools, and all manner and shapes of steel. In fact all the varieties of materials that this busy industrial center is capable of producing, and going further afield, we are now inspecting buildings being erected as additional facilities with government-supplied funds.

There are now ten naval officers and some 230 civilian inspectors employed in the Pittsburgh district. The salaries of the civilian inspectors range from \$1620 to \$3800 per annum. The greater bulk of them are in the \$2000-odd dollars bracket, and very few receive the higher rates of pay.

All inspectors are, when possible, drawn from registers supplied by the Civil Service Commission. Should there temporarily be no available names on the register of eligibles, we are

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permitted to make temporary appointments subject to later approval by the Civil Service Commission; consequently we are in such cases at pains to make only selections which we deem can qualify with the Commission which has final authority in the matter, and if satisfied, tenders a probational appointment.

However, during the present emergency we are permitted to retain the temporary appointees regardless of their ratings by the Commission, if their services are satisfactory.

The maximum age limit for appointees during normal times is 53 years, but for the present emergency this restriction has been advanced to 65 years. The Civil Service requirements for the minimum rating at $1620 per annum are a common-school education and at least two years' practical experience in inspection work, but an engineering degree may be substituted for the two years' practical experience. We prefer the college man as our experience has been that he makes the better inspector. Nor do we care to take on men well along in years as a great deal of our inspection work requires physical stamina.

Occasionally an initial appointment is made in a higher grade when an exceptionally well-qualified applicant presents himself, or the services of a specialist are required.

The Pittsburgh district operates a well-equipped chemical laboratory at Munhall. This laboratory can also perform physical tests, but these are usually done at the contractor's works in the presence of an inspector.

HOW THE PRIORITIES SYSTEM WORKS

The Act of June 28, 1940, authorized the President to apply priorities. This authority was delegated to the Office of Production Management, which acts through its Director of Priorities, and with the advice of the Priorities Board, its committees and agencies.

Although legal means have been provided to enforce priorities of delivery of Army and Navy orders over those for foreign and private accounts, the present system is based upon voluntary cooperation of government and industry.

Priorities have the function of giving preferential treatment to implement the purchasing and production of munitions and accomplish this function by increasing productive capacity by preferential completion of facilities, and by attaining a balanced production of military components, thus insuring the supply of more urgent and important munitions at the expense of those of a lesser degree of urgency or importance. These results are attained by interchanging delivery dates of orders before articles are completed, diverting the delivery of completed items from one order to another, and accelerating manufacturing process of certain items at expense of others with competing delivery dates, or by allocating output among customers in accordance with their relative importance.

The Army and Navy Munitions Board, a committee of the Priorities Board, in conjunction with the Navy Department, has classified and subclassified the various projects under its cognizance into groups of projects, which groups have been assigned definite priorities. By such procedure, if the material being furnished the Navy for one of these projects is difficult to obtain, it is placed on the critical list. Priorities may be automatically assigned by the inspector having cognizance of the contract for such materials.

This method is the system of preference ratings through which extension or re-extension of certificates is issued by officers in the field to assure such degree of preferential treatment in the fulfilling of the contract as is necessary to meet required delivery dates. Thus the supervisors of shipbuilding, inspectors of machinery, and inspectors of naval material during the present emergency act with the full authority of the Navy Department, taking final local action to the greatest possible extent both in prosecuting the construction of Naval vessels and in expediting their completion with the utmost vigor.

The nation is now engaged in a great National Defense program—a vast project which as late as only two years ago would not have been considered possible to undertake.

The tonnages and costs of the materials involved under the Lend-Lease Bill, that needed for a greatly expanded and fully equipped Army, and for a two-ocean Navy with the necessary bases for its operation, are so stupendous that without a smoothly functioning and adequate priorities system, nothing but chaos would result.

LABOR PROBLEMS

In the Navy Department's offices in Washington, and in the navy yards and naval inspection districts throughout the country, the thousands of civilian employees all have Civil Service status. Their jobs are protected by law, their promotions and salary increases follow a very definite plan.

With respect to labor employed by manufacturers having contracts for Navy material, we insist upon compliance with the governing laws, some of which are of quite recent origin. The Walsh-Healy Act requires that in any contract between a government bureau or agency, and a corporation, where the materials manufactured or furnished amount to over $10,000, there shall be incorporated several very definite specifications affecting labor. One requires the payment of not less than the minimum wages as determined by the Secretary of Labor to be prevailing in that industry. Another requires that no person employed by the contractor shall be permitted to work in excess of eight hours in any one day or in excess of forty hours in any one week without receiving overtime pay. Other provisions of that law prohibit the employment of boys under 16, and girls under 18, and convict labor, and require working conditions to be both safe and sanitary.

Suitable penalties are provided for the breach or violation of any of the stipulations in these contracts, and the naval inspector insures that the law is obeyed.

However, when differences arise between management and labor and a plant is shut down or picketed, the Naval Inspection Service adopts a neutral attitude, and does not enter into the matter other than to report existing conditions to the Navy Department. The Department of Labor, not the Navy Department, then steps in with the Conciliation Service to mediate the differences and start the wheels rolling smoothly once more.

A Federal statute adopted in June, 1940, prohibits the employment of aliens on what we term "classified" Navy contracts, that is, work that is of a secret, confidential, or restricted nature, unless specific approval is secured from the Navy Department in each particular case. The Inspector of Naval Material is responsible for the application of this rule, which seems a very wise provision under the existing emergency situation.

An earlier law of 1917, passed during World War I, relating to espionage, has recently been revived and strengthened, and while the paramount responsibility belongs to the F.B.I., the Navy's inspection force keeps its eyes open as well. It should be understood that the Navy looks upon labor as a whole as a loyal, patriotic group of citizens.

At present our organization is devoting a great deal of time to progressing the work being done by various contractors to insure that prompt deliveries of material are made, and in some cases to advance the delivery dates of badly needed items.

In connection with this work we try to render every assistance to a contractor who requires materials or additional machine tools for the prosecution of his work.

Our job is to do our part in providing our country with a two-ocean, fully integrated Navy that will be able to afford our country protection in time of need. Only then will our first line of defense become a reality.

MATERIAL HANDLING *With* FORK *and* PLATFORM TRUCKS

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FOR some time past, industry in general has been alert in modernizing its machinery and scrutinizing its processing operations, endeavoring to squeeze out of its costs almost infinitesimal fractions of a cent, particularly where volume production existed. Floor layouts, covering successive operations in certain groups of equipment, have been given careful consideration, and micromotion studies have been employed with a high degree of success in reducing motions at particular pieces of equipment or at the bench. It might be said that this type of cost-reduction activity occupied the center of the stage, focusing a major portion of the attention of management and overshadowing the possibilities in other fields, particularly those involving indirect workers.

Naturally, as perfection is more nearly approached in one field, even though it be subjected to almost continual change, the more fertile other fields are apt to become. Generally speaking, that is just what has happened; we have been employing men to pick the pennies out of dark and hidden corners, but have been overlooking the half dollars representing material-handling cost reductions.

There are many other reasons why this condition was permitted to exist to such a large degree for so long a time:

1 Relatively low cost of unskilled labor.

2 Idle space, particularly after boom periods.

3 Storage areas subject to almost continual moving, owing to the expansion of manufacturing facilities.

4 Economic conditions have been such that usable equipment was allowed to remain in service even though new and better equipment was on the market which would more than justify its use because of operating economies.

The lack of a reasonably sustained period of fair business activity was, no doubt, a large contributing factor.

To give some idea of the tremendous factor materials handling is in industry, the eight apparatus works of the General Electric Company and the Bridgeport Works of the Appliance and Merchandise Department received well over 1,000,000 tons of material in 1940. In the author's opinion, the ability of a manufacturing concern to make a profit today on manufacturing operations is almost directly dependent upon its ability to handle economically incoming materials, work in process, and finished products, unless fortunately it is not in a highly competitive field.

The skid-and-platform-truck method, either hand or electric or both, is the most commonly accepted method of industrial handling today. This is particularly true in consumer-goods industries, but not to the same degree in the capital-goods industries. The history and development of the pallet-fork-truck method of handling which supersedes the skid-platform-truck method is a most interesting story in itself. In passing, it should be mentioned that forks were first applied to unit loads of tin plate and that users of tin plate contributed materially in the development of fork trucks. Before the General Electric Company adopted them nearly 5 years ago, the larger steel mills and automobile manufacturers had further demonstrated the possibilities of their application.

Naturally the author's company employs all types of handling equipment such as cranes, conveyers, hoists, tractors, and trucks of all kinds, although it cannot be denied that some of the more or less permanently installed or highly specialized equipment has had to give way to the more flexible and portable equipment. The author does not wish to give the impression that his company favors any one method over all others by devoting a major portion of this paper to the use of pallet fork trucks and auxiliary equipment. Attention is given this method because at the Bridgeport Works there is volume production of goods which, while they are bulky, are adaptable to handling on pallets.

In order to give a better idea of the particular job at this plant it may be stated that such appliances are handled as radios, washing machines, ironers, fans with blades from 10 to 48 in. diam, toasters, waffle irons, coffee makers, sunlamps, and food mixers, and wiring materials such as switches, sockets, fuses, conduit products, wire, and cable.

CHANGE IN HANDLING METHODS SIMPLIFIED BY PLANT EDUCATION

The success in undertaking a revolutionary change in handling methods is in a large measure dependent upon the interest created by a well-planned educational program. Once the decision was made that fork trucks had a definite place in the material-handling picture at the Bridgeport Works, various groups ranging from top management to planners and stock-room foremen were shown representative types of materials from all manufacturing sections, arranged in various types of unit loads on either single- or double-faced pallets. By seeing a fork truck handle, transport, and tier all loads that we might conceivably encounter, these groups could visualize the handling of materials with which they were directly concerned. It was at one of these demonstrations that a large reel was first handled by running the forks directly under the reel flanges, Fig. 1. Today fork trucks, equipped with 1000-amp-hr batteries push-button-controlled motorized adjustable forks, Fig. 2, are handling all reels up to 78 in. diam, and also larger process drums, because of the speed with which the load can be picked up and deposited, remarkable maneuverability in congested areas, and the flexibility of the equipment.

Many present unit loads bear slight resemblance to those originally exhibited; for example, compare the unit load of 100 motors with plywood separators, shown in Fig. 3, with the original load of 64 motors shown in Fig. 1.

The possible application of newly developed equipment, continual changes in manufacturing facilities, and new handling problems make it essential to have a well-organized plan for perpetual material-handling activities. In a large plant, subcommittees in each of the manufacturing and service depart-

Presented at a meeting of the Materials Handling Division, Metropolitan Section, New York, N. Y., February, 19, 1941, of The American Society of Mechanical Engineers.

FIG. 1 PARTIAL VIEW OF EDUCATIONAL DEMONSTRATION

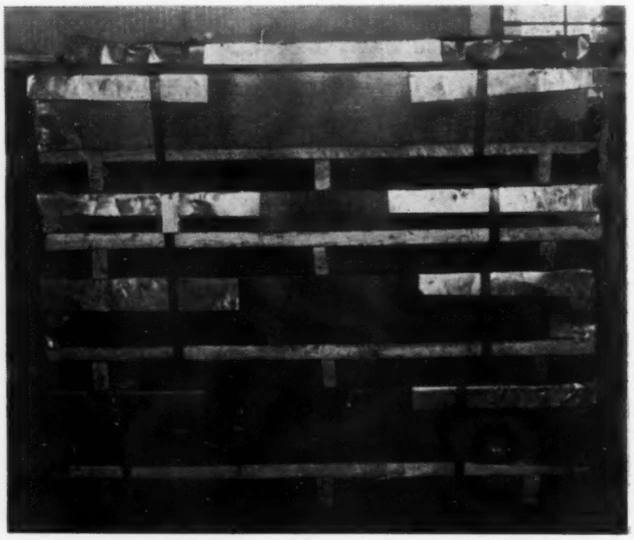


FIG. 4 UNIT LOADS OF SHEET STEEL, AS RECEIVED FROM VENDOR

FIG. 2 TRUCK EQUIPPED WITH MOTORIZED ADJUSTABLE FORKS CARRYING 7500-LB REEL

FIG. 5 COILED STEEL ON OPEN-FACED PALLETS BEING PLACED IN STORAGE

FIG. 3 INTERPLANT SHIPMENT OF MOTORS TIERED IN STOCK

FIG. 6 FORK AND PLATFORM TRUCKS OPERATING IN TRANSITION

FIG. 7 UNIQUE UNIT LOADS OF FINE WIRE ON SPOOLS

FIG. 10 THE FIRST HAND-LIFT-PALLET TRUCK

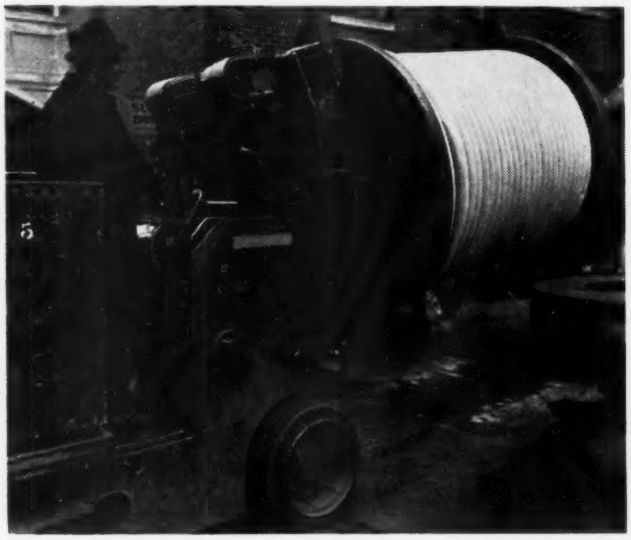


FIG. 8 PROCESSING DRUMS DESIGNED FOR USE WITH FORK TRUCKS

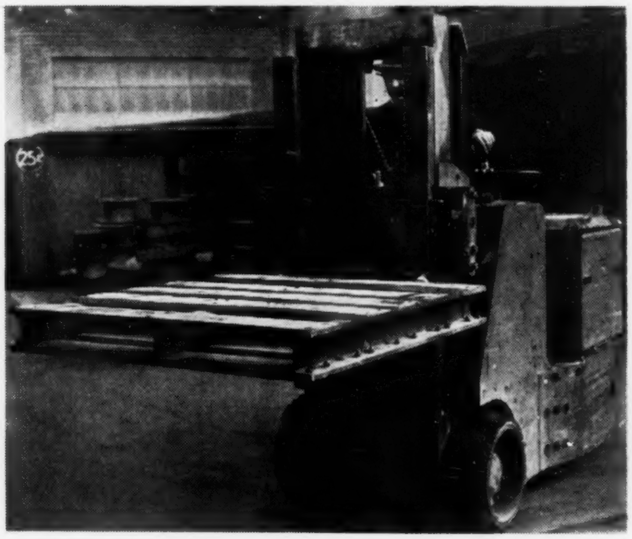


FIG. 11 WOOD AND STEEL PALLET USED FOR GENERAL PLANT WORK

FIG. 9 HEADROOM OF SMALL-APPLIANCE WAREHOUSE UTILIZED WITH MINIMUM HANDLING

FIG. 12 RECENT EXAMPLE OF SUBSTANTIAL AND PROPERLY DESIGNED IMPROVED BRIDGE PLATE

ments, functioning under the direction of a plant supervisor, have proved satisfactory. In the General Electric Company the plant supervisor is a member of the General Material Handling Committee of the company, which is composed of representatives from the various works. The plant subcommittees serve well for disseminating information and gathering ideas for similar applications elsewhere in the company. By having well-established lines of contact, improved handling methods for interplant movement can satisfactorily be coordinated.

SOLUTION OF TYPICAL HANDLING PROBLEMS

Suppliers of steel sheets have done a splendid job in working up unit loads, as shown in Fig. 4. Heavy metal coils when strapped to a simple inexpensive open-faced pallet can be very efficiently handled with a fork truck because of the short length and width of load. Fig. 5 shows how double-unit loads are transported from freight car to storage.

During the transition period while both fork and platform trucks are in use in any department, pallet loads may be handled universally by using them in combination with skids as shown at the right in Fig. 6. Note the manner in which castings may be stacked for handling and storage and the unit load of disks on the platform.

Various sizes of spools of fine wire are being received in very substantial unit loads as shown in Fig. 7. The pack minimizes the handling of the empty spools with a dunnage weight considerably below that prevalent under former practices. Where fork trucks are the major medium of transportation, it is essential that all auxiliary equipment be built around fork trucks wherever practical. Fig. 8 illustrates a vulcanizing drum over 6 ft in length, designed to receive the forks, overcoming the wide traverse and at the same time reducing the possibility of damaging the lead-covered cable to a minimum. Though the handling of the large variety of work-in-process materials is a very fruitful field, it is more difficult to produce results than in the handling of either incoming or outgoing materials.

Fig. 9 illustrates the arrangement and operation of one of our finished-product warehouses today. The unit loads are brought into stock and tiered by means of a powered fork truck. Where necessary, the load from which partial withdrawals are made is placed on the floor adjacent to the remaining stock of that item. As a large percentage of our shipments do not involve unit loads of any one item, pallet loads of miscellaneous items are made up with the aid of the hand-pallet lift truck shown, after which they are transported to the freight car or truck by means of a powered truck. The normal hand truck is now available, powered by either a gas- or battery-operated unit, and manually drawn stackers are on the market for tiering pallets and large individual items, such as washing machines.

PALLET CONSTRUCTION REQUIREMENTS

There are a few general items of equipment which should be given primary consideration in meeting certain requirements. First and foremost are the type and dimensions of pallet. Pallets may be made of soft- or hardwood, a combination of wood and steel, or all steel. Past experience with skids is a good guide to follow; serious consideration should be given to steel pallets if steel skids occupied a definite place in the past.

Fig. 10 shows a double-faced wood pallet, designed for use with a hand-pallet lift truck as well as a fork truck. It will be noted that the platform passes between the upper and lower decks of the pallet and, as the pallet is lifted from the floor, wheels are lowered between the first opening from the end of the truck. For a 48 × 48-in. pallet, which is the general standard for the author's company, openings $6^1/_2$ in. wide must be provided, approximately 6 in. from each end of the pallet, to receive the lifting wheels. The hand-pallet truck illustrated was the first one developed for handling closed or double-faced pallets. Just as more substantial metal-bound wooden skids found general application, a more substantial and similar pallet, shown in Fig. 11, was developed for company use. Although this pallet costs approximately twice as much as a hardwood pallet, it is more than justified for hard general plant usage. It is made up of hickory slats and corrugated-steel stringers, and all wood edges are protected with metal.

The importance of substantial and properly designed bridge plates or toeplates, as shown in Fig. 12, cannot be stressed too strongly from the safety and maneuverability standpoints.

In the use of fork trucks the wheels under the uprights serve as a fulcrum and, as the truck is loaded nearer capacity, these wheels carry the total load. The weight of the plate can be held to a minimum by proper reinforcement rather than by a heavier thickness of plate. Fork trucks are required to make extremely sharp turns when emerging from freight cars in order to remove some loads, consequently we incorporate a guard rail which also adds to the capacity of the plate. Where man-clearance has been provided between freight cars and platforms, fork trucks have been known to go down between the car and the platform, throwing the operator.

Note the reinforcement on the underside by means of channels and angles which also serve as stops to keep the bridge plate from shifting without the customary practice of nailing down. Bridge plates are provided with slots for the insertion of a link chain, so that the fork truck may transport the bridge plate by means of the forks carrying the chain; the plate can be readily placed in position in the car in this manner.

Our experience has been that, in addition to the anticipated labor and space or rental savings, we also benefit as follows:

1 Reduced spoilage from improved and less handling.

2 Better utilization of manufacturing equipment.

3 Unit-load principle facilitates maintenance of perpetual inventory records.

4 Promotion of cleanliness and good housekeeping.

5 Possible damage from sprinklers confined to area underneath them as materials are 5 or 6 in. above floor level.

Although we have effected substantial economies, we feel that we have only scratched the surface and will endeavor to deliver unit loads of incoming materials to the point of consumption in every case where practical and, in a similar manner, during processing and after completion of the product. Naturally, products completed on an assembly conveyer in many instances can best be transported to storage by means of extending the conveyer. During transit, either incoming or outgoing, unit loads may be heavier or larger, made up of several smaller units for handling within buildings or on upper floors.

It is hoped that the period of time, before railroads and trucking companies have facilities for handling unit loads at transfer points for less-than-carload shipments, may be shortened materially by the combined efforts of shippers and equipment suppliers. Many coastal and coast-to-coast steamship lines have been using the pallet-fork-truck method for loading and unloading hulls for two years. An attempt is also being made to have pallets considered as dunnage by the railroads when bearing a load. If this important step is accomplished, it will open a tremendous field and speed up the facilities for the handling of less-than-carload shipments in the same manner.

To show how earnestly the movement of unit loads is being treated, a company has been formed to further the "palletizing" of loads. In addition to supplying wood pallets for all purposes over a wide area, the company operates a coordinating service to eliminate the one-way transportation of empty pallets. This practice has proved very successful by larger manufacturers making rotating use of pallets for interplant shipments.

SERVICE EXPERIENCES *With the Newer* CONDENSER-TUBE ALLOYS

THE operators of steam surface condensers have come to realize in the last decade that the condenser-tube alloys of admiralty, Muntz, and arsenical copper have limitations in installations where the circulating water is brackish or is contaminated with sewage or industrial wastes and have sought new alloys for this service. The manufacturers have developed a group of new alloys including among others aluminum-brass, aluminum-bronze, copper-nickel, copper-nickel-zinc, and copper-nickel-tin to meet the demand for condenser tubes with superior corrosion- and erosion-resistant properties. The newer alloys are replacing admiralty, Muntz, and arsenical copper in many marine and land stations where the chemical and mechanical action of the circulating water is severe.

In 1936, the A.S.M.E. Special Research Committee on Condenser Tubes in its Annual Report covered the experiences of several operating companies with trial installations of new alloy tubes in odd lots up to one half of a condenser and noted that cases had been reported in which entire condensers had been retubed with new alloy tubes. It found that in most cases the special-alloy tubes had not been in service long enough to obtain a satisfactory service record. In the last 4 years, the period of service has been extended sufficiently for more definite conclusions to be reached. Also, in the intervening time, the operating companies have made a comparatively large number of complete installations of the newer group of alloys and a still larger number of trial installations.

It is of interest to note that admiralty, Muntz, and arsenical-copper condenser tubes, supplied with uncontaminated circulating water from fresh-water inland rivers and lakes, are giving from 70,000 to 120,000 service hours with very few failures. It is not uncommon for these condensers to continue in service 20 to 30 years without retubing.

GENERAL COMMENTS BY CONDENSER-TUBE MANUFACTURERS

The position which the newer alloys occupy in the industry is reflected in part in the following statements made by condenser-tube manufacturers:

"It is noteworthy that condenser tubes of the aluminum-brass type are continuing to be used and in increasing amounts, particularly in power-station condensers using salt water. Condenser tubes of the 70-copper 30-nickel type are being used increasingly in marine condensers and this alloy has come to be recognized as showing the best all-round corrosion resistance to salt water aboard naval and other vessels, ...

"In this connection, however, it should be noted that the copper-nickel alloys have not proved satisfactory for use in power stations located at tidewater and, in particular, using contaminated harbor water.

"There is some evidence to indicate that aluminum-brass is as satisfactory in resisting sulphur and sulphide corrosion as admiralty and is used to a certain extent in the oil-refinery industry where such conditions obtain.

"Aluminum-brass and 70-30 cupronickel, on the basis of our experience, definitely appear to be much more resistant to erosion-corrosion attack than the older-type alloys."

One condenser manufacturer submitted a list of 5 aluminum-brass condenser-tube installations with 35,000 to 36,000 service hours and 17 cupronickel (70-30) installations with 6000 to 15,000 service hours still operating with the original tubes.

"Aluminum-brass has proved itself superior to admiralty in many locations using salt water for circulating purposes with relatively high velocities through the tubes and turbulent water conditions in the condenser. However, there are other factors in connection with the circulating water which combined with high velocity may adversely affect aluminum brass.

"Copper-nickel 80-20 and 70-30 alloys have shown better performance in sea water with high velocities. Their general increasing use in the marine field and virtual adoption as 'standard' for naval craft indicate their growing popularity.

"High-copper tin bronze has proved, so far, that it will give longer service life in either laboratory or field tests where circulating waters are high in acid. It has also proved very satisfactory in waters high in sewage or decaying organic matter."

COMPARISONS OF ADMIRALTY AND ALUMINUM-BRASS CONDENSER TUBES

A public-utility company on the West Coast using sea water at velocities of 5 to 6 fps has admiralty tubes installed in three condensers and aluminum-brass tubes in the fourth. Since the three condensers with admiralty tubes went in service, there have been 35, 17, and 14 per cent failures after 47,000, 59,000, and 89,000 service hours, respectively. In the fourth condenser the aluminum-brass tubes have been in service 20,000 hours with but one failure.

The 1936 Progress Report of the A.S.M.E. Special Research Committee on Condenser Tubes included an account of an experiment being conducted at a plant on the eastern seaboard in which 300 hard-drawn aluminum-brass tubes of foreign manufacture were installed with a similar number of new admiralty tubes of domestic manufacture in a condenser otherwise equipped with more than 9000 admiralty tubes. The tubes were installed in parallel rows in all four quadrants of the condenser. The normal life of admiralty tubes in this condenser is from 7 to 10 years. The results of this test to date are:

"In 1938, after 8 years of service in the first pass, 47 per cent of the admiralty tubes had failed against 6 per cent of the aluminum-brass. In the second pass, there were 3 per cent failures for the admiralty and none for the aluminum-brass. The percentage of failures for the admiralty in the first pass was considerably greater than we normally allow before retubing. These tubes evidently had about the normal life of 7 years. The admiralty tubes showed the characteristic inlet-end failure, while the aluminum-brass tubes were all in excellent condition. Several of the aluminum-brass tubes, recorded as failing, were withdrawn for examination, but the cause of failure could not be determined. Subsequently, they were cut up for chemical analysis. The admiralty tubes in the first pass were replaced and the test continued with the second-pass tubes.

"In October, 1940, the second-pass tubes were inspected after 10 years of service with the following results: Admiralty 33.3

1940 Report of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS Special Research Committee on Condenser Tubes: A. E. White, Chairman; D. C. Weeks, Vice-Chairman; P. A. Bancell, R. A. Bowman, D. K. Crampton, C. A. Crawford, H. M. Cushing, R. E. Dillon, J. R. Freeman, Jr., V. M. Frost, C. F. Harwood, G. C. Holder, W. C. Holmes, W. B. Price, J. S. Rodgers, M. F. Stack, H. A. Staples, W. R. Webster; Rear Admiral S. M. Robinson, U. S. N., Director, Bureau of Ships, U. S. Navy Department.

per cent failures and aluminum-brass 1.6 per cent failures. The difference in appearance of the two types of tubes was marked. The aluminum-brass tubes were all in excellent condition, except at the very entrance, where the admiralty ferrules had worn away, exposing the ends of the tubes to the erosive action of the water. The ends were worn but there was no sign of impingement attack. On the other hand the admiralty tubes were all in very poor condition. The first-pass aluminum-brass tubes continued in good condition.

"The wide difference in appearance of the two types of tubes after the first year or two led to the supposition that there was some voltaic action tending to protect the aluminum-brass tubes at the expense of the admiralty. Subsequent tests have shown that admiralty metal is placed lower on the electrochemical scale than almost all other condenser-tube alloys. Consequently, there is a tendency of the admiralty to protect the other alloys at its own expense. Strictly comparable results therefore cannot be obtained when different-alloy tubes are installed in the same condenser. However, in our own case we are convinced that the voltaic action between the two alloys accounts for only a small portion of the difference in their behavior."

A company having a steam power plant obtaining tidal salt circulating water from the estuary of a river in Brazil, varying in quality roughly from 25 to 75 per cent sea water and in temperature at the condenser inlet from 75 to 91 F, reported that it was necessary to replace admiralty condenser tubes that failed due to plug-type dezincification after 8 to 12 years of service. Replacements were made in two condensers with aluminum-brass tubes of British manufacture. In one condenser, the aluminum-brass tubes have been in service about 42,000 hr without any failures having been reported.

COMPARISONS OF ALLOYS BY SHORT TIME TESTS

The company making the experiment, comparing 300 hard-drawn aluminum-brass tubes with an equal number of admiralty tubes, reported another test as follows:

"Three years ago, we started a test which was designed to permit a fairly quick determination of the relative value of the various alloys used or proposed for use in condenser-tube manufacture. All of the American manufacturers and several English manufacturers were invited to submit sample tubes for this test. Practically all furnished the desired tubes, so that we were able to test a total of 39 tubes representing 12 different alloys, not including variations of standard alloys, as submitted by nine different manufacturers. In order to be consistent, all tubes were ordered 1 in. outside diam × 18 gage × 18 ft long.

"Short lengths (14 in.) of tubes were placed in a metal rack which in turn was mounted in the inlet water box of one of the main-unit condensers. The samples were so installed that they were completely insulated from the rack and from each other. The rack was placed about 8 in. in front of the tube sheet so that the samples were directly in the flow of the circulating water and subjected to its full turbulence. Each sample was accurately weighed at the start of the test and also at 6-month intervals thereafter. At the end of each 6-month period, the tubes were moved progressively along the rack in order to reduce the effect of any usual local condition. The completion of the test was set at about 12,000 hr for the less resistant alloys, such as admiralty, and 18,000 hr for the cuproaluminum alloys and other more resistant materials. In order to eliminate mechanical wear which occurred at the ends of several samples, the final weight was determined per foot of length by cutting off both ends of each sample. This weight when compared with the original weight per foot of length gave the percentage loss in weight for the sample. These figures were in turn corrected to a common time basis of 10,000 hr.

"Complete chemical analysis and physical data were obtained for every sample.

"A wide variation in the performance of the tubes is noted. The lowest rate is 0.75 per cent for an aluminum-brass tube, while the highest is 21.25 per cent for a red-brass tube. A study of the data indicates a distinct grouping of the tubes according to their chemical compositions. The first group includes only those tubes containing aluminum; the second group, the cupronickel tubes; and the third the admiralty and miscellaneous alloys. The divisions between the groups are marked and indicate that this grouping is no accidental occurrence.

"A study of the aluminum-brass samples indicates that the annealed tubes are superior to the hard-drawn tubes and, further, that the optimum aluminum content is close to 2.5 per cent. We note this in contrast to the present-day tendency of American manufacturers to keep the aluminum content at or under 2 per cent."

Another public utility in the East on an inland river, contaminated with a large percentage of acid mine drainage, has experienced rapid thinning of tube walls due to acid-water attack. The severity of attack was such that a set of 18-gage admiralty condenser tubes had to be replaced after $2^1/_2$ years. These tubes had corroded to the extent that approximately one third of the original metal remained. The condenser tubes are attacked evenly throughout their entire length, the loss of metal being so uniform that tube walls are often paper-thin when failure occurs. There is no discoloration which indicates dezincification, or localized loss of metal which denotes impingement attack.

"Analyses of the river water indicate the presence of iron sulphate, which is in the ferric form due to exposure to atmospheric oxygen. It is the presence of ferric sulphate, which is an oxidizing agent, in combination with acid water, that causes the highly corrosive action experienced."

The test procedure, the analysis of the test data, and the conclusions reached are recorded as reported:

"Condenser tubes of various alloys have been tested in actual service, in order to find a material more resistant than admiralty metal. It is realized that in many cases the amount of deterioration of a condenser tube cannot be measured by loss of weight of the tube but, with the particular type of corrosion experienced in this case, the rate of loss of weight is a satisfactory method of finding expected tube life with most metals. In determining the performance of a metal as condenser-tube material, a number of tubes of the metal to be tested and an equal number of admiralty tubes are weighed and installed in the same part of a condenser, a record being made of the location of each tube. At the end of the test period, both sets of tubes are removed after first being cleaned. Each tube is weighed, cut into 3-ft sections, and each section micrometered for wall thickness, inspected internally for roughness or discoloration, and checked roughly for weakening of the metal by bending or flattening. Since both sets of tubes are exposed to the same water for the same length of time, and being in the same part of the condenser, transfer approximately the same amount of heat, an accurate comparison between admiralty metal and the metal being tested is obtained.

"In analyzing results of the test two factors are determined, namely, 'relative corrosion rate' and 'uniformity factor.' Relative corrosion rate, which is the ratio of loss of metal from the test tubes to the loss of metal from admiralty tubes, is found by dividing average per cent loss of weight of the test tubes by average per cent loss of weight of the admiralty tubes. Uniformity factor is determined by dividing the average loss in wall thickness by the maximum loss in wall thickness. These two factors indicate the rate of loss of metal and uniformity of

loss of metal from the test tubes as compared to admiralty tubes. It is necessary to make the tests on a comparative basis, using some metal as a standard, rather than on a time basis, because of the variable character of the river water.

"When tests on condenser tubes were first started, a number of tubes were placed on test inside the condenser and a number of tubes were tested outside the condenser by causing river water to flow through them; cleaning them each time the condenser was cleaned. It was found that results obtained on tubes tested outside the condenser did not agree with results obtained on tubes installed in the condensers, indicating that the final answer on performance of condenser tubes can be found only by trial in actual service.

"Results of tests are given in Table 1.

TABLE 1 RELATIVE CORROSION RATE AND UNIFORMITY FACTOR FOR TUBES OF VARIOUS COMPOSITIONS

Composition of tube, per cent	Relative corrosion rate	Uniformity factor
70 Cu-29 Zn-1 Sn (admiralty)	1.00	0.79
70 Cu-30 Ni	1.69	0.78
76 Cu-22 Zn-2 Al	1.20	0.75
99.7 Cu-0.3 As	1.19	0.67
70.5 Cu-2 Al-1.5 Ni-26 Zn	1.17	0.66
70 Cu-29 Ni-1 Sn	1.02	0.63
95 Cu-5 Al	0.99	0.61
88 Cu-10 Zn-2 Sn	0.68	0.78

"Relative corrosion rate was lowest with tubes composed of 88 per cent copper, 10 per cent zinc, and 2 per cent tin. These tubes retained their original toughness at the end of the test period to a much greater extent than admiralty tubes and, since their uniformity factor was the same as that of admiralty tubes within the limits of error of the test, their comparative life is expected to be inversely proportional to their relative corrosion rate, or approximately $1^1/_2$ times the life of admiralty tubes. It is probable that this alloy would be superior to admiralty metal in any condenser where the cooling water is contaminated with acid mine drainage. Aluminum-bronze tubes, which were developed to resist impingement attack where water velocity is high, became quite rough internally, the loss of metal being so irregular that failure would occur after the loss of a relatively small amount of weight. These alloys are definitely inferior to admiralty for the conditions present. Other metals, which resist salt water and alkaline water, do not resist the acid mine drainage present. Tubes which had not been pickled after the final anneal were tested on a comparative basis with tubes that had been pickled and no difference in performance could be detected, indicating that, if the black skin is allowed to remain on the tube when it is manufactured, performance or life of the tube will not be noticeably affected.

"Small plates of a number of different alloys were tested by suspending them in the water box of one of the condensers, an admiralty-metal plate being included in each group as a standard for comparison. These tests do not duplicate conditions obtained with condenser tubes, but were conducted as a search for promising alloys. Results of these tests are given in Table 2.

"The sample of pure nickel had corroded entirely away during the test period, the exact time when the complete loss of weight occurred being unknown. Therefore, it is known that the sample was attacked more than 3.85 times as rapidly as the admiralty sample. The extremely poor resistance of pure nickel to corrosion by the available river water probably explains the poor performance of most alloys of this metal. The alloys containing a high percentage of chromium are the only ones found to date which completely resist the corrosive action of the water.

TABLE 2 RELATIVE CORROSION RATE FOR TEST PLATES OF VARIOUS COMPOSITIONS

Composition of metal, per cent	Relative corrosion rate
70 Cu-29 Zn-1 Sn (admiralty)	1.00
18 Cr-8 Ni-74 Fe	0.00
18 Cr-82 Fe	0.00
14 Cr-86 Fe	0.01
12 Cr-88 Fe	0.10
5 Cr-0.5 Mo-94.5 Fe	5.92
76 Cu-22 Zn-2 Al	0.49
94.5 Cu-5.4 Sn-0.1 P	0.61
96 Cu-3 Si-1 Mn	1.19
91 Cu-3.5 Zn-1.5 Fe-3.5 Si	1.36
96 Cu-3 Si-1 Zn	1.19
70 Cu-30 Ni	2.01
85 Cu-15 Zn	0.95
88 Cu-10 Zn-2 Sn	0.53
70 Cu-28.9 Zn-1 Sn-0.1 Sb	0.95
75 Cu-20 Ni-5 Zn	1.32
99.92 Cu-0.025 P, plus some silver	0.25
98.9 Cu-0.7 Zn-0.4 Cr	0.49
88 Cu-8 Zn-4 Sn	0.50
80 Ni-14 Cr-6 Fe	0.03
Nickel	3.85 plus

"The condenser-tube corrosion problem has been reduced by finding a more suitable alloy than admiralty metal, but it is by no means considered solved. At present, condenser tubes of seven different alloys are being tested in our condensers. These alloys are as follows:

18 Cr-8 Ni-74 Fe (stainless steel)
18 Cr-82 Fe (stainless iron or chrome iron)
88 Cu-8 Zn-4 Sn
99.92 Cu-0.025 P, plus some silver
98.9 Cu-0.27 Zn-0.45 Cr
85 Cu-15 Zn
Phosphorized admiralty

"Due to improved quality of river water, use of 16-gage tubes instead of 18-gage tubes, and use of 88 per cent copper, 10 per cent zinc, 2 per cent tin alloy instead of admiralty metal, expected life of condenser tubes is now 3 to 4 times what it was prior to 1933. The search for better tube material is being continued with the hope that a metal will eventually be found so suited to the conditions which exist that condenser-tube corrosion will no longer be a serious problem."

COMPARISONS OF GROUPS OF ALLOYS IN SERVICE

A power plant on the Atlantic Seaboard using harbor water for its condensers, containing considerable sewage and factory wastes, reported the following:

"Prior to the installation of aluminum-brass-alloy tubes, most of our failures had been due to inlet-end attack and to dezincification. With the aluminum tubes, a considerable portion of the failures are due to cracking and splitting. The remainder are caused by pit holes.

"Inlet-end corrosion has been almost entirely eliminated by the use of aluminum-brass tubes. As the greater proportion of the aluminum-brass tubes installed have been hard-drawn, most of the cracks are probably due to vibration. The installation of battens between the tubes has largely eliminated this trouble."

Another public utility on the Atlantic Seaboard has experimented with several of the newer alloys in a number of condensers in which admiralty condenser-tube life has varied from about 10,000 to 35,000 service hr for 18-gage tubes and from 35,000 to 60,000 hr for 16-gage tubes. The life of the tubes is

usually considered complete when 20 to 25 per cent of the tubes have failed.

The reporting company comments as follows:

"Nickel-alloy tubes have been in service (16-gage tubes) for about 60,000 service hr with 14 and 22.5 per cent failures. Contrasted with this, there are 15,000 aluminum-brass tubes of British manufacture in service for 60,000 hr with no failures due to corrosion or erosion. Aluminum-bronze tubes have been in service over 90,000 hr with only 3 per cent failures.

"Tubes made with 20 to 30 per cent nickel content do not have as much resistance to inlet-end cavitation as aluminum-bronze and aluminum-brass tubes installed in the same condenser. Percentage failures of these tubes after 60,000 hr were 14 and 22 per cent for the nickel tubes against 1 to 2 per cent for concurrent service on the aluminum-alloy tubes.

"Inspection of the 80 per cent Cu, 16 per cent Zn, 2 per cent Al, 1 per cent Ni tubes, with no failures after 33,000 hr, shows no signs of inlet-end corrosion, whereas, practically all of the failures of tubes, of a similar composition in another unit, were from this cause.

"It can be seen from our experience, therefore, that the alloys containing aluminum have a much longer life than nickel-alloy or admiralty tubes. This is due to the fact that dezincification does not occur and inlet-end corrosion is greatly decreased. In general, it can be said from our experience that aluminum-bronze tubes give the longest life, then aluminum-brass, then the nickel-bearing alloys, and finally admiralty."

A company on the Atlantic Seaboard, using salt circulating water, contaminated with sewage and with acids from the ash-disposal system, reports the following:

"At only one of our plants have we used any of the aluminum or nickel alloys. In one condenser we have installed for experiment 10 aluminum-brass tubes, 10 copper-nickel (80-20), and 10 copper-nickel (70-30). All of these tubes were installed in the first pass of the two-pass condenser on December 18, 1937.

"In another condenser, we have installed for experiment 250 aluminum-brass tubes in the first pass of one side of the condenser.

"In the two condensers with which we have had trouble, corrosion took place at the inlet end, extending for a distance of about 6 in.

"The aluminum and nickel alloys apparently are about as susceptible to corrosion as the admiralty metal in so far as this particular station is concerned."

CONDENSER DESIGN AND THE NEWER ALLOYS

"The Bureau of Ships continues to specify the use of (70-30) copper-nickel tubes and tube sheets in the construction of all heat exchangers, including condensers employing salt water as the cooling medium. From a comparison with other alloys under actual service conditions (70-30) copper-nickel tubing has demonstrated high corrosive-resistant qualities. With the zinc content of this alloy kept within the limit of 0.5 per cent, the failure of condenser tubes from dezincification is practically eliminated. It has been definitely established that admiralty-metal tubes are capable of withstanding direct impingement action of either steam or salt water better than (70-30) copper-nickel tubes, although admiralty tubes are subject to failure as the result of dezincification. In the design of a condenser, extreme care must be taken to avoid the impingement of steam directly onto the copper-nickel tubes. The Bureau of Ships has experienced several failures on the steam side of copper-nickel tubes directly attributable to the erosive action of auxiliary exhaust steam. In the case of present construction, internal baffling is provided over the auxiliary exhaust-steam-inlet connection with a view of deflecting the steam toward the path of the incoming steam and away from the tube bundle.

"In order to retain the high corrosive-resistant qualities of (70-30) copper-nickel and further to minimize the direct impingement attack of salt water onto the tube ends and tube sheet, the Bureau of Ships has made it a standard practice to incorporate the following requirements in the design and construction of condensing equipment:

(*a*) Use of similar materials for the tubes, tube sheets, water boxes, and circulating-water piping.

(*b*) Installation of ample zinc protectors in such a manner as to effect a good metallic contact and to result in the minimum of water turbulence.

(*c*) Provision of a venting manifold on the top of the inlet water box for the purpose of venting effectively the salt-water system before the direct impingement of air bubbles onto the tube ends takes place.

(*d*) Installation of plastic (bakelite or neoprene) condenser-tube protectors in the ends of the condenser tubes in the inlet pass so that the direct impingement of circulating water onto the ends of the copper-nickel tubes will be eliminated.

(*e*) Increasing the depth of the water boxes to distribute the incoming circulating water, thereby reducing its velocity at the tube entrances.

(*f*) In many cases, the application of a satisfactory protective coating has greatly added to the satisfactory service life of the tubes and tube sheets.

(*g*) Improvement in the design and construction of the circulating-water-injection piping system so as to effect streamline flow along an area of gradual increasing divergence and at the same time minimize turbulence and eddy currents.

(*h*) Limit the maximum circulating-water velocity to 7 fps for main condensers under full power conditions and to 4.5 fps for dynamo condensers under all conditions. At the same time, the velocity of circulating water past the flange of the injection connection is limited to 9.5 fps for main condensers and 6.5 fps for dynamo condensers.

(*i*) Improvement in the design and construction of the main injection nonreturn valve, so as to effect the minimum degree of turbulence and obstruction in the path of the circulating water.

(*j*) Experimentation with various types of directional baffles or vanes installed in the inlet water box for the purpose of improving the uniformity of water distribution over the tube-sheet area.

(*k*) In the case of two-pass condensers, the venting between water-box division plates across inlet and outlet passes warrants serious consideration.

(*l*) The necessary precautions should be taken to avoid overrolling and overbelling of the tubes when making up the condenser-tube joint. This is especially important in the case of copper-nickel tubes, in view of the relative softness of the metal.

(*m*) Provide the first ten rows of tubes in line with the incoming steam with tubes of heavier gage than those existing throughout the remaining tube nest.

"In order to combat the effects of inlet-end impingement attack and still retain the high corrosive-resistant qualities of (70-30) copper-nickel, the Bureau of Ships has developed an ideal plastic condenser-tube-end protector. After several years of arduous effort augmented by numerous laboratory experiments, tube-end protectors fabricated from bakelite, neoprene, and combinations of bakelite and neoprene were developed. It has been found that these inserts have a long service life and ideally protect the inlet ends of the tubes. The bakelite inserts are preshrunk by baking after manufacture and, consequently, can be slipped into the tube ends by hand and held in place

(*Continued on page 658*)

NONLUMINOUS RADIATION *to* TUBE BANKS

By D. H. Fax

GRADUATE STUDENT, THE JOHNS HOPKINS UNIVERSITY, BALTIMORE, MD.

Designers of heat-transfer equipment have long been aware of the fact that nonluminous gases transmit heat to cold surfaces by radiation, as well as by convection and conduction. It is also known that only such gases as carbon dioxide, water vapor, and ammonia emit appreciable amounts of energy by means of radiation, whereas, gases such as oxygen and nitrogen, which are composed of symmetrical molecules, do not emit thermal energy at temperatures met in industrial practice. It has further been established that the radiant energy emitted from a gas mass to its bounding surface is a function of the temperature of the gas and the product term *PL*, in which *P* is the partial pressure of the radiating constituent, such as carbon dioxide or water vapor, and *L* is the average length of the path of the radiant beams through the gas to the bounding surface, which in turn is a function of the shape of the gas mass.

Extensive work has been done and considerable data have been published on the relations existing between radiant energy, gas temperature, and the term *PL* for various gases. A recent paper[1] by Hottel and Egbert gives a review of this work and attempts to correlate the results of many researchers. A difficulty, which has long existed in the application of these data to actual design, has been the problem of evaluating *L*, the mean length of the radiant beams, for irregular gas shapes. Up to the present time, when it was desired to estimate the amount of radiation from gases flowing through banks of tubes, the literature supplied the value of *L* for only two definite tube arrangements, namely, tubes with centers on equilateral triangles, where the tube diameter is equal to the clearance and, similarly, where the tube diameter is equal to one half the clearance. The evaluation of *L* for any other case involved great approximations. With new information presented in the paper[1] referred to, it becomes a simple matter to determine *L* for any gas shape to a sufficiently accurate degree. It is the purpose of the present paper further to clarify the situation and to present this information in a form convenient for design purposes.

Hottel and Egbert state that, at very low pressures of the radiating gas, the emission approaches proportionality to *PL*, and the value of *L* approaches as a limit the expression, four times the gas volume divided by the area of the bounding walls, and is independent of the gas shape, the nature of the gas, or its temperature. Since the proof of this very useful theorem is nowhere to be found in the literature, the following proof is here presented

The spot at the center of the base of a hemisphere of gas "sees" the same thickness of gas in all directions; consequently, the value of *L* for radiation to this spot is equal to the radius of the hemisphere. As the gas pressure approaches zero, the total radiation to this spot (at a given temperature and pressure) approaches proportionality to *L;* we are interested in finding the factor of proportionality.

[1] "The Radiation of Furnace Gases," by H. C. Hottel and R. G. Egbert, Trans. A.S.M.E., May, 1941, pp. 297–307.

If i is the rate of heat release in the hemisphere in Btu per cu ft per hr, an elementary volume dV will radiate idV Btu per ht in all directions, and an elementary area normal to and at a distance x from the elementary volume will receive $\frac{idV}{4\pi x^2}$ Btu per sq ft per hr. If the normal to the area makes an angle θ with the line joining the area and the volume dV, the elementary area will receive $\frac{idV}{4\pi x^2}\cos\theta$ Btu per sq ft per hr. Since the hemisphere is a figure of revolution, we can take as our elementary volume a ring, shown in Fig. 1, of cross section

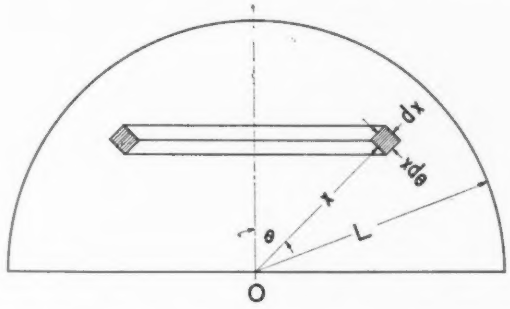


FIG. 1 EVALUATION OF EMISSION TO CENTER OF BASE OF HEMISPHERE

$xd\theta dx$ and of mean circumference $2\pi x \sin\theta$; hence $dV = 2\pi x^2 \sin\theta d\theta dx$. The rate of emission to the point O from this elementary volume will be $dE = \frac{idV}{4\pi x^2}\cos\theta = \frac{i \sin 2\theta dx d\theta}{4}.$ Since we are dealing with a gas of extremely low pressure, each element of volume radiates to the walls just as though no other gas elements were present; consequently, to find the total energy per unit area per hour received at O, we simply integrate the last expression over the entire hemisphere, that is

$$E = \frac{i}{4}\int_0^{\pi/2}\int_0^{L} \sin 2\theta dx d\theta = \frac{iL}{4}\int_0^{\pi/2} \sin 2\theta d\theta$$

or

$$E = \frac{iL}{4}$$

Next, consider an irregular solid figure of volume V and of surface area S. The total heat released from this volume of gas per hour is iV, the heat absorbed by the bounding walls in the same time is $E_{avg}S$, that is, $\frac{E_{avg}}{i} = \frac{V}{S}$. The value of L at any point on the surface has been shown to be given by $4E/i$; the mean value of L for the entire figure will be $4E_{avg}/i$. It follows that the mean value of L is $4V/S$, which was to be proved.

It should be repeated that this is the value of L at zero gas pressure. When the gas pressure has finite values, E is no

longer proportional to PL and the actual value of L will be less than $4V/S$. The authors of the previous paper[1] state further that, for the range of PL encountered in practice, a satisfactory approximation consists in taking 85 per cent of the limiting value.

APPLICATION OF METHOD TO BANKS OF TUBES

The main purpose of this paper is to apply this method of calculating the mean length of the radiant beams to banks of tubes of any arrangement, and to present this information in a manner convenient for design purposes. The upper insert in Fig. 2 shows a section of a bank of in-line tubes. Term A is the greater center-line spacing of the tubes, B is the smaller center-line spacing, and D is the outside tube diameter. The volume of gas per unit thickness normal to the paper, included in the simplest repeating pattern, as in the group of four tubes shown in the insert by means of the dotted line, is $V = AB - \frac{\pi}{4} D^2$; the tube surface per unit thickness normal to the paper that bounds this volume of gas is $S = \pi D$. Therefore, the limiting value of L is given by $L_0 = \frac{4V}{S} = \frac{4AB - \pi D^2}{\pi D}$ or $\frac{L_0}{D} = \frac{4}{\pi}\left(\frac{B}{A}\right)\left(\frac{A}{D}\right)^2 - 1$. Taking 85 per cent of this gives $\frac{L}{D} = \frac{3.4}{\pi}\left(\frac{B}{A}\right)\left(\frac{A}{D}\right)^2 - 0.85$. This same analysis applies to

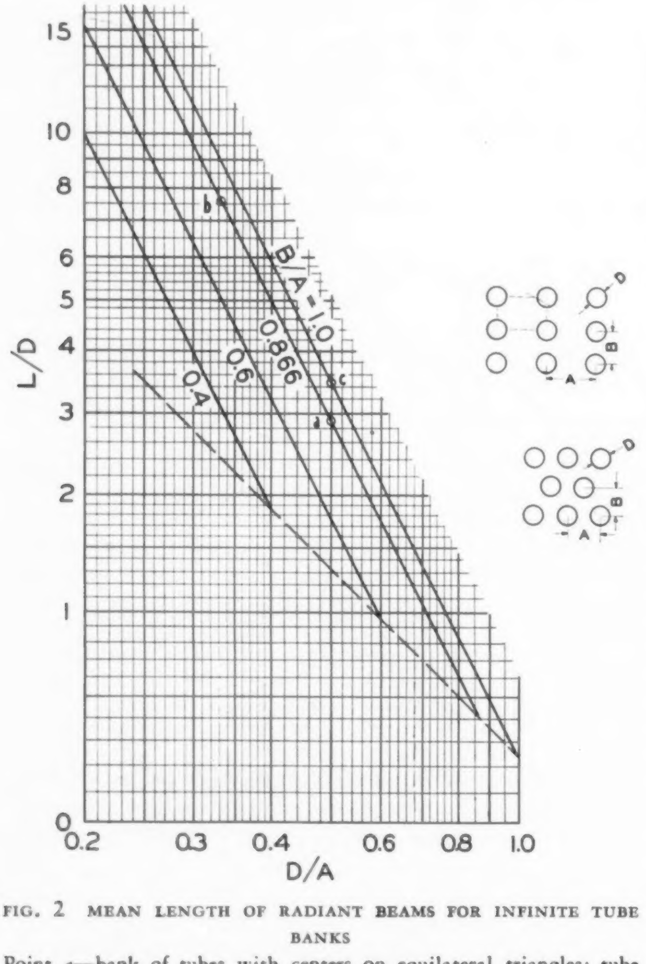


FIG. 2 MEAN LENGTH OF RADIANT BEAMS FOR INFINITE TUBE BANKS

Point *a*—bank of tubes with centers on equilateral triangles; tube diameter = clearance

Point *b*—bank of tubes with centers on equilateral triangles; tube diameter = one-half clearance

Point *c*—tube centers on squares; tube diameter = clearance

staggered tubes or to any tube configuration as long as A and B are measured at right angles to each other.

Fig. 2 is a plot of $\frac{L}{D} + 0.85$ against D/A on logarithmic coordinates, with B/A as the parameter. Thus, for example, in a bank consisting of 3-in. tubes, with centers on equilateral triangles where the clearance is 6 in. between the outside of the tubes, the value of B/A is 0.866 and the value of D/A is 0.333. This corresponds to point *b* in Fig. 2, and it is observed that, for average conditions occurring in practice, the value of L in such a tube bank is 7.6 times the tube diameter, or 22.8 in. Interpolation for values of B/A other than those shown is easy because it will be noted that, at the intersections of the solid lines with the broken line, the values of the ratios B/A and D/A are equal.

Fig. 2 holds only for infinite tube banks, since only in such a case is the gas completely confined by the bank itself. However, Fig. 2 can be applied to finite banks without serious error, since, for a bank of any considerable depth, the amount of energy which "leaks" out of the bank is but a small fraction of that absorbed by the tubes themselves.

Service Experiences With the Newer Condenser-Tube Alloys

(*Continued from page 656*)

securely by the use of a special bakelite cement. It has also been definitely established that bakelite is not adversely affected by high temperatures and by the corrosive effects of salt water since it is chemically and physically inert with respect to the surrounding metals in close proximity.

"The Bureau of Ships has under actual service test aboard ship a condenser installation containing tubes made of the following different alloys aside from the standard installations of admiralty and (70-30) copper-nickel alloy:

Copper-nickel-tin	Nickel-copper (monel)
Aluminum-copper-nickel	Dorium "D" metal
Copper-nickel-zinc	Copper-nickel (hard drawn)

"To date the performance of (70-30) copper-nickel tubes has been most satisfactory and none of the alloys mentioned has proved superior to (70-30) copper-nickel. The condenser installations in which the tubes are provided vary from 100 sq ft to 10,000 sq ft in condensing surface. The length of service, during which these tubes have been under test, varies from 12 months to 6 years. The area of greatest failures has been either at the top of the tube bank or in the path of the incoming circulating water. In the case of admiralty tubes, most failures have been attributed to local pitting and plug-type dezincification; layer-type dezincification usually occurs in tubes that have been in service for many years. In the case of (70-30) copper-nickel tubes, most failures have been attributed to erosion at the inlet ends, steam impingement wearing down the tube wall from the steam sides and to localized pitting usually resulting from the presence of a foreign particle.

"The question of satisfactory condenser-tube performance is closely associated with the design and construction of the condenser for which the tube serves. An ideally designed condenser will add considerably to the life of ordinary condenser tubes such as admiralty, whereas, a poorly designed condenser will depreciate considerably the service life of the most expensive alloy. The Bureau of Ships has constantly appreciated this situation and has continually endeavored to improve the design and construction of condensers especially as far as the water side is concerned."

A Decade of Progress *in* PETROLEUM PRODUCTION, RESEARCH, *and* TECHNOLOGY

By W. J. HUND and A. G. LOOMIS

SHELL DEVELOPMENT COMPANY, EMERYVILLE, CALIF.

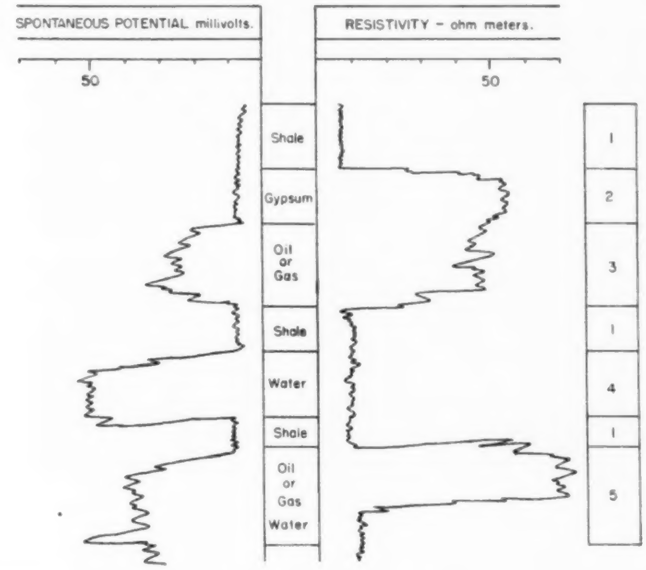


FIG. 1 ELECTRIC WELL LOG

IN THE last decade the oil industry has been transformed from an enterprise for getting oil out of the ground as quickly as possible, treating it by a few simple processes, and selling it to an eager market not too critical of quality, into a great scientifically controlled industry. This control has extended from prospecting through all the stages of well drilling, production, refining, and synthesis to the careful tailor-made product fit to the needs of the consumer. In this brief paper only a few high lights of this development will be given.

It must still be said that oil, like gold, is where you find it. The search is however greatly aided by the sciences of geology and geophysics, as well as by topographic and aerial surveying. At present the most useful geophysical method of reconnaissance and detail exploration is the seismic reflection method; next in importance, chiefly for reconnaissance, is gravimetric exploration. Magnetic and chemical methods are probably third in present scope.

The record of geology and geophysics has been very impressive; for example, in 1920 the chances of a wildcat well were 1 in 100, contrasted with the 1938 record in Louisiana where 67 wells opened 16 new fields. In that area, in recent years, wildcats drilled on technical advice were successful two to three times as often as those drilled without such advice. Another example is the Gulf Coast, where, in the 23 years preceding geophysical exploration from 1901 to 1923, thirty-one fields were discovered, largely on the basis of surface evidence, whereas the following nine years, from 1924 to 1932, saw the discovery of 51 fields as a result of geophysical and geological technique, and the six-year period to 1938 brought 116 new discoveries, largely by means of the reflection seismograph, gravimeter, and other geophysical methods. Similarly, California had only one major discovery between 1928 and 1935, but as a result of reflection seismic methods 16 new oil fields with total proved reserves of $1^1/_2$ billion barrels were discovered from 1936 to 1938.

There is one type of reservoir that has defied all geophysical surface finding techniques, the so-called stratigraphic trap, or in general, structures of very low relief. The great East Texas field is of this type. It is believed that the low-relief structure must predominate in future discoveries, and it is for this reason that great interest is being shown in the new soil gas exploration method, where soil gas, existing either free or adsorbed on soil particles, is analyzed for very small quantities of hydrocarbons, on the theory that the soil over gas-oil accumulations must contain hydrocarbons diffusing from depth to surface. This geochemical method has the important advantage, if it should prove successful, that it has the possibility of finding oil or gas directly, rather than merely a favorable structure for such an accumulation, which is the limit of geology or geophysics.

DEVELOPMENTS IN WELL DRILLING

The drilling of wells has also undergone a marked change during the last ten years—the cable tool or standard rig, inadequate for deep drilling, has been almost entirely displaced by the rotary drill, which was made practical by the development of scientifically controlled drilling muds to control high-pressure formations.

In the early days of the industry a gusher was cause for celebration; now, with the use of the column of mud fluids to hold back the pressure within the formation, it would be a sign of loss of control. The most recent advances in the technique of control of a drilling well by mud fluid have resulted from engineering studies of all of the requirements of such a fluid together with the application of colloid chemistry. For example, barium sulphate is added to the clay slurry to increase the hydrostatic head against the formation; such heavy muds are ordinarily very viscous but may be reduced to water-like consistency by the addition of viscosity-reducing chemicals in small amounts; the muds are made thixotropic, that is, a light gel forms when the fluid is at rest and breaks easily under mild stresses, thus suspending the cuttings in the hole during periods

Based on address by A. G. Loomis before San Francisco Section of The American Society of Mechanical Engineers, San Francisco, April 24, 1941.

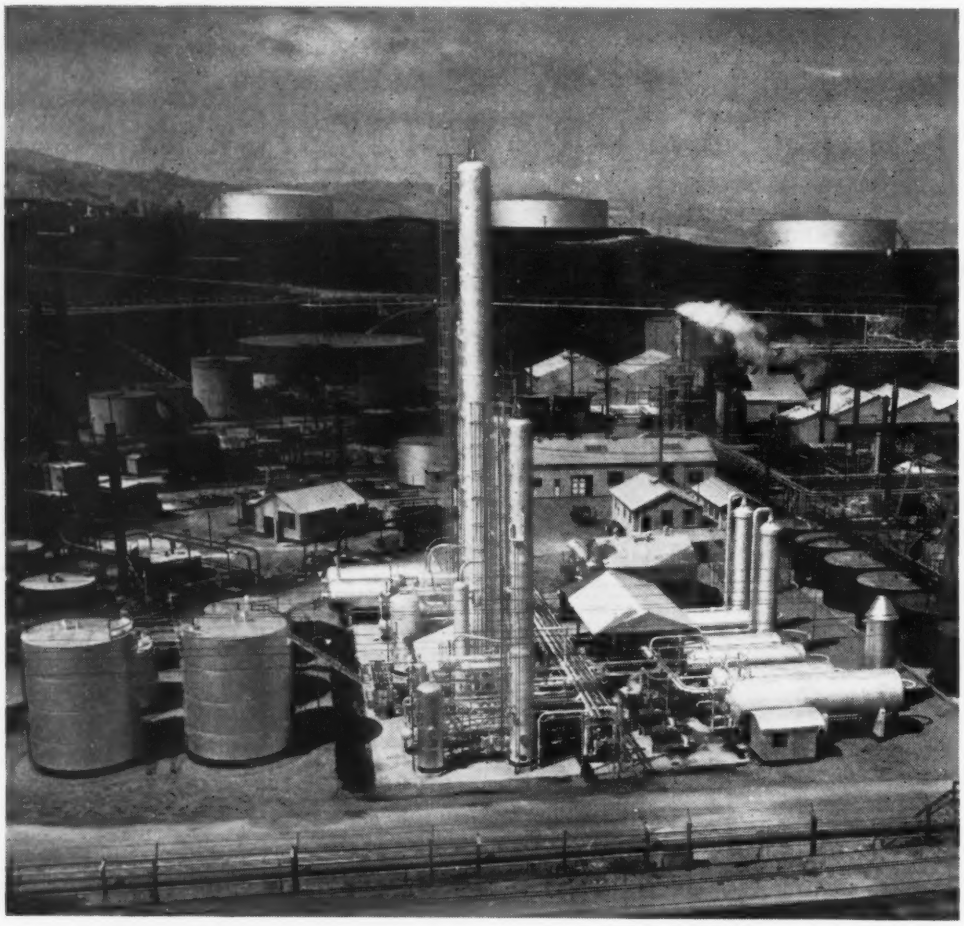


FIG. 2 ALKYLATION PLANT, SHELL OIL CO., INC., MARTINEZ, CALIF.

of enforced shutdown; by the addition of protective colloids muds are made resistant to the flocculating powers of strong brines, and thus excessive water losses to the formation are avoided. Excessive water losses often result in loss of the hole caused by caving of the shale beds. Oil-base muds possessing thixotropic properties have recently been developed. The ultimate flow of oil into the well may be seriously impaired by the entrance of water from a water-base mud, a circumstance which is avoided by the use of oil-base muds for the drilling-in process.

In present-day practice, although the penetration of an oil-bearing formation is sometimes indicated by the presence of oil in the mud fluid, chief reliance is placed on various logging methods.

Important advances during the last decade have been the continuous core record and the examination of drill cuttings, leading to identification of the formations by paleontological and mineral analysis; also electrical logging, which gives information of the lithology and fluid content of the formations. The type of information obtained in electric logging is illustrated in Fig. 1 which gives curves of the electrical resistivity and the spontaneous potentials, measured by lowering suitable electrodes into the mud-filled hole. Reading downward the following formations are encountered:

Horizon 1. A shale layer, characterized by its low resistivity (i.e., high brine content) and low spontaneous potential (i.e., low permeability).

Horizon 2. A bed of high resistivity and low permeability, possibly gypsum, coal, or a highly mineralized sandstone or limestone.

Horizon 3. An oil or gas sand, both resistant and permeable. A sand containing exceptionally fresh water might show up similarly.

Horizon 4. A salt-water sandstone or limestone, permeable and conductive.

Horizon 5. A sand whose upper section is oil- or gas-bearing and whose lower section is water-bearing.

In addition to the type of information illustrated in this figure, electric logs can be used to correlate beds encountered in adjoining wells and thus detect the faulting or dipping of underground strata. Minute details in the logs are often so perfectly reproduced from one well to another that the strata may almost be said to be fingerprinted by the character of the curves obtained.

Further information is obtained from temperature surveys; these, taken in conjunction with electric logs, assist in distinguishing between water-bearing, oil-bearing, and gas-bearing formations.

Recently these methods have been augmented by radioactivity logs, which are particularly useful in locating and correlating formations in cased wells, where the electrical method cannot be used. Thus oil-bearing horizons which were cased off when the well was drilled to deeper horizons may be produced following gun perforation of the casing at the proper level.

EXPLOITATION OF NEW FIELDS

Although the oil industry is almost 82 years old, practically no attention was paid to basic research in the production of oil earlier than about fifteen years ago, for in the earlier days all emphasis was placed on rapid production. As supply finally outstripped demand the industry began to change its viewpoint, and the emphasis shifted from the function of wells to the control of production, thence to conservation, and finally focused on the reservoir itself and its performance.

A knowledge of the pressure-volume-temperature relationships of the reservoir fluid is necessary to decide the most efficient methods for the exploitation of a new oil field. In the last few years much progress has been made in using such data.

Of primary importance is their use in conjunction with subsurface pressure and temperature measurements to determine whether the reservoir is under gas drive, water drive, or a combination gas and water drive. After establishing the nature of the reservoir, the fluid content (connate water, oil saturation), oil shrinkage, etc., and the areal extent of the structure, the production technologist is in a much better position to estimate the oil and gas reserves of the reservoir and plan proper exploitation methods.

In the course of the development of the field, many problems arise, the intelligent handling of which requires the use of the laboratory volumetric data on the original fluid. Only three

will be mentioned: the proper location and spacing of wells, the utilization of the natural water drive under the most favorable conditions, and the utilization of an efficient gas drive in the absence of a strong water drive (including pressure maintenance or repressuring).

A special problem in pressure-volume-temperature relationships is the so-called distillate reservoir. In deep reservoirs where the pressure is high, hydrocarbon mixtures have often been found of composition intermediate between purely gas fields, where methane is very high, and crude-oil mixtures, where methane is low. When the pressure and temperature of the gaseous phase in these reservoirs is reduced, a liquid is separated, because of the phenomenon of retrograde condensation. There are over 100 known fields in the United States that show this behavior. The new Paloma field in California is one of these.

By application of the laboratory pressure-volume-temperature data, proper conditions are worked out for each reservoir in order to give an indication of the maximum yield of condensate.

Hydrocarbons remaining in the gas phase are ordinarily removed in a high-pressure absorption plant and the lean gas is recompressed to inject them again into the reservoir from which they were taken, so-called pressure maintenance. This step has the threefold purpose of sweeping out as much rich gas as possible, of maintaining the reservoir pressure above the dew point, thus avoiding condensation and hence irrecoverable loss in the reservoir sand, and of conserving gas. Over a billion cubic feet of gas per day is now being returned to such reservoirs. Practically half the recoverable hydrocarbons suitable for gasoline may be lost in the reservoir if the gas is not recycled to maintain pressure. This practice, where it is economically practical, represents perhaps the best form of conservation of a natural resource that has been practiced by industry. It involves the production of a large volume of fluid, recovering less than 10 per cent of it and returning over 98 per cent of the remainder to the reservoir for future gas reserves.

The modern approach to the understanding both of the recovery and of the rate of production of oil involves the study of the properties of the rock together with the properties of the oil-gas-water systems occupying the pore volume of the rock. In addition to the properties of the gas-oil system, as just discussed, we must also know how the presence of connate water in the rock affects the flow of the oil and gas, and how the oil in the rock affects the flow of the gas. The wetting properties of the system of rock and mixed liquid are also of the utmost importance.

Such data can be used in many ways; for example, to infer the oil saturation of the sand from the ratio of flow of gas to that of oil from the sand; and this inference may be made not only for the region close to the well but for various more distant regions by taking due consideration of the variation of solubility with pressure and the compressibility of the gas. This leads to a method for evaluating oil properties. Other applications are in the prediction of recovery by pressure maintenance as compared with straight depletion of a reservoir, and as a guide in secondary recovery methods.

While secondary recovery of oil by injection of water (or gas, as in pressure maintenance) has been practice for some time, it has been much more widely used in the last ten years. Secondary recovery is perhaps the most important problem facing the industry; and this is understandable when it is realized that in

FIG. 3 PUMPING UNITS, ALKYLATION PLANT, SHELL OIL CO., INC., MARTINEZ, CALIF.

known fields there is believed to be a greater quantity of oil not recoverable by ordinary methods than has ever been produced.

Water flooding is used (1) to produce oil which could not be recovered by natural methods of production because of lack of natural energy, as for example shallow sands such as those in the Bradford, Pa., area, or in Oklahoma, or at Kern Front, California, (2) to produce dead or unsaturated crude commonly present in stripper fields, (3) to recover efficiently oil in tight sands, being considerably more efficient than gas drive for this case, (4) as a positive control of oil production in accordance with strict proration requirements, and (5) because the profit can be calculated quite accurately.

Recovery by water flooding depends on both percentage saturation and permeability. Thus for Mid-Continent sands of low permeability (say 5 md) the final saturation cannot be reduced below 18 per cent, while for those of higher permeability (200 md) the figure is 15 per cent. For Bradford, the estimate is 25 per cent. Even this latter represents a recovery of 40 per cent of a 40 per cent saturation, or the production of 6000 bbl per acre out of 15,000 bbl not otherwise recoverable. In fact a considerable fraction of the total increase of estimated oil reserves in this country, from 5,000,000,000 bbl in 1925 to 20,100,000,000 bbl in 1940, represents not new discoveries, but oil regarded at the earlier date as nonrecoverable.

CONVERSION OF CRUDE INTO FINISHED PRODUCTS

The conversion of crude oil into finished products has undergone as far-reaching changes during the last decade as has the exploration and production of petroleum, and these have resulted from the same trend toward establishing operations on a scientific rather than empirical basis.

Until 1930 developments were almost entirely controlled by sales and engineering departments. The most pressing demands were for greater quantities of the products which the sales forces thought the public wanted. Since the object of producing, refining, and marketing facilities for crude oil and its products was mainly one of transportation, either from below the surface up, from the field to refineries, from refineries to markets, or in the refineries mainly from tanks through equipment, either hot or cold, to other tanks, the technical problems opened a wide field for the activities of engineers.

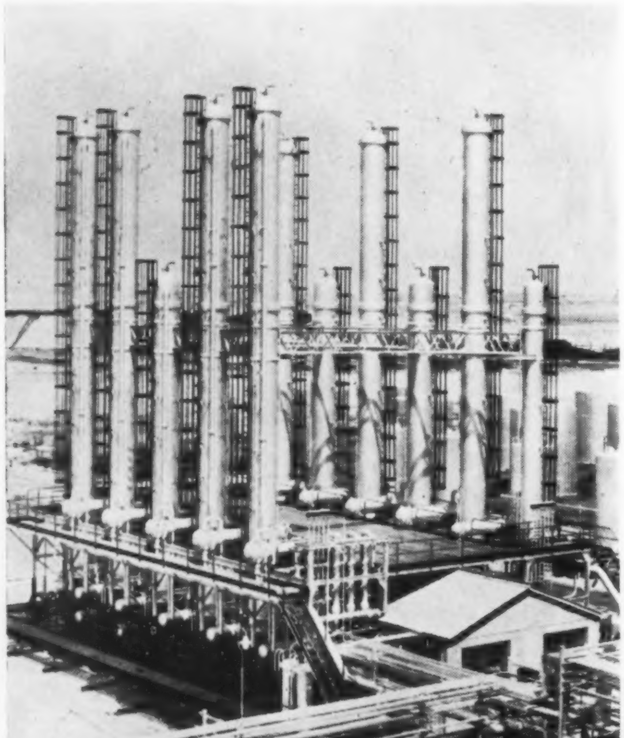


FIG. 4 FRACTIONATING COLUMNS, SHELL CHEMICAL COMPANY, DOMINGUEZ, CALIF.

As long as the sales departments had for each product a definite picture in mind as to quality wanted by the public, the task of the chemist was mainly to develop test methods suitable to measure the properties concerned, and to do trouble-shooting in connection with the application of conventional refining methods. These were mainly distillation, thermal cracking, treating with acid and caustic soda, filtration over absorbing clays, and plumbite (doctor) treatment, as they had been used for nearly 50 years. Improvements during that time had been mostly in equipment.

For a decade, however, chemists and motor engineers had been wondering whether the public (and sales force) were qualified to know what they wanted, and had attempted with great devotion to find out why products behave in use as they do and what properties they should have to satisfy.

This resulted in some advancement in the quality of products and in refining methods, but no considerable amount of money was available either for this type of research or for the equipment and expense of manufacturing better products as long as the problems of producing more oil and more products were far more important than those of improving quality.

However, the oversupply of products and low profitability, or entire lack of it, in the early thirties made the industry quality-conscious. It became evident that there would eventually be a market only for products of superior quality.

Since 1930 research carried out by chemists and engineers on quality and performance and on revolutionary methods of producing quality has been the outstanding factor in the development of the industry.

An example of this trend is the development of superior types of gasoline from the standpoint of power production, which function is closely related to antiknock value. Among other things this has made possible present-day supercharged aircraft engines, with outputs up to almost one horsepower per pound of engine weight.

Synthetic branched-chain paraffin hydrocarbons are especially valuable as constituents of high-antiknock gasoline. From 1934, when Shell produced the first commercial quantities of iso-octane, rapid progress has been made in the synthesis of such fuels by polymerization, hydrogenation, and alkylation processes. The cold acid polymerization process utilizes the isobutylene in refinery cracked gas (butane-butylene fraction) and produces, after hydrogenation, a product which is almost 100 per cent iso-octane (2,2,4-trimethyl pentane), the standard of antiknock value. This process has now been supplanted by hot acid polymerization, which utilizes the normal butylenes in conjunction with isobutylene to double the amount of polymer obtainable from a given feed. When hydrogenated, the product compares favorably with iso-octane itself, both as to lead susceptibility and blending value.

The potential supply of high-octane fuel from a given refinery olefin feed is again doubled by the sulphuric-acid alkylation process, in which isobutane or other isoparaffin is linked directly to an olefin to produce a branched-chain isoparaffin of 92–94 octane number (unleaded) in a single step. The olefin (usually C_4 fraction) is premixed with an excess of isobutane and then is fed to an emulsion of acid and reacted hydrocarbon which is rich in isoparaffin but substantially olefin free. By

this method of operation undesirable side reactions are suppressed. The temperature of operation is 0 to 20 C. An interesting engineering side light is that good mixing is an essential to the success of the process, and in one design of plant this is achieved by means of a circulating pump acting through additional reaction space in which intimate contact is maintained by the velocity of flow through jets and baffles. The acid used has an initial strength of 98 to 100 per cent and is discarded when the strength has dropped to about 85 per cent.

A marked advantage of the sulphuric-acid alkylation process is the great range of possible feed stocks. While with any of the various polymerization processes 100-octane fuels with reasonable amounts of lead are possible only with butane-butylene feeds, sulphuric-acid alkylation successfully utilizes olefins in the range of three to seven carbon atoms, and both isobutane and isopentane.

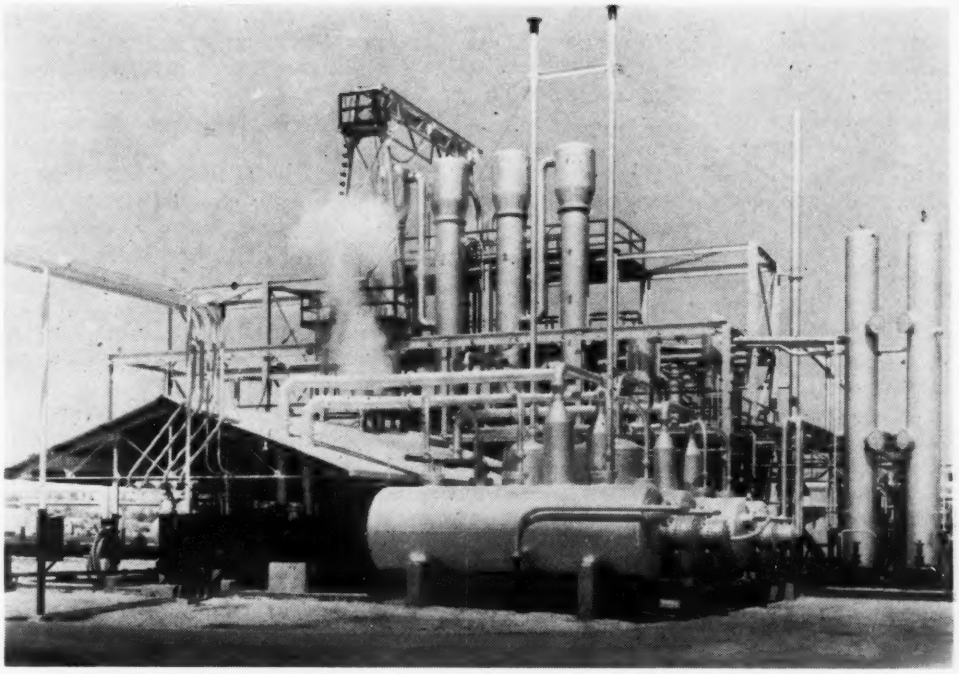


FIG. 5 REACTOR PLANT, SHELL CHEMICAL COMPANY, DOMINGUEZ, CALIF.

Views of the alkylation plant at the refinery of Shell Oil Company, Inc., Martinez, are given in Figs. 2 and 3.

Another outstanding development is catalytic cracking. The intensive study and engineering development of thermal cracking in the last twenty years has led to a situation in which the possibility of further improvement in efficiency of operation vs. quality of product appears to be slight, unless some radically different principle be introduced.

Within the last three years this has been achieved in the use of catalysts which so influence the chemical reactions occurring during the cracking process that both the yield and quality of the resultant gasoline are improved to a notable degree.

The essential nature of catalytic cracking consists in the treatment of distillates heavier than gasoline over a solid catalyst at temperatures of 750 to 1000 F and pressures of about atmospheric to 60 psi. The catalysts employed are usually silica-alumina combinations from natural clays or chemical synthesis.

The gasoline from catalytic cracking has 78 to 80 octane number, about 10 points higher than the thermal product. The gas is made richer in three and four carbon-atom components, useful for producing high-octane synthetic fuels and for making chemical derivatives. Finally, the residual gas oil suffers less degradation and has superior qualities for use as Diesel fuel or burner oil.

It follows from the decreased production of methane and ethane and the lessened degradation of gas oil, that the over-all liquid product yields are improved over the thermal process. In many cases it is possible to adjust the product distribution more efficiently than in thermal cracking, allowing the attainment of better yields of gasoline or gas oil, or of both products.

In present commercial plants for catalytic cracking the raw oil is passed over a fixed bed of heated catalyst until the accumulation of carbon on the catalyst impairs its activity. For this operation a period of ten minutes to six hours is employed, depending on the particular conditions and stocks. The oil is then switched to an active mass of catalyst and the used catalyst is regenerated by burning the carbon in a controlled stream of air. The process is then repeated, the catalyst having an ultimate life of many months.

An entirely new type of catalytic cracking has recently been announced. In this process the solid catalyst is continuously circulated as a finely divided powder which accompanies the oil vapors into the cracking zone, after which it is mechanically separated from the cracked vapors and is regenerated with controlled air and recirculated to the cracking zone. Because the powdered catalyst is entirely gas-borne, it may be treated according to the usual laws of flow applying to fluids. The significance of this type of operation is that it is continuous instead of intermittent as in the fixed-bed process.

Octane number is an expression often used rather casually, even by technologists. It is important that we do not fall into the snare of taking the word for the fact. Put specifically, we should make sure that the laboratory rating of antiknock quality be really expressive of performance in automobiles on the road and in supercharged aviation engines. It is gratifying that the industry has made real progress in this direction. One difficulty of course is the wide range of operating conditions encountered in practice.

Fairly satisfactory results have been achieved in the automotive test field by varying only compression ratio, leaving other conditions constant. In the aviation test field, however, such simplicity could not give reasonable correlation with service. In the first place there are two distinct types of aircraft operating conditions—take-off and cruising. Fuels vary widely in their relative ratings under these two sets of conditions, hence ratings must take both into account. Moreover engines larger than the laboratory type should be used, at least as a check with full scale performance.

Recognition of these problems, and the intensive effort to solve them, is already rewarding the petroleum industry with real guidance in the search for better types of fuels.

As mentioned before, these better fuels have already had a great effect on airplane performance and will have a still greater effect as they continue to influence engine design, so as to take

full advantage of the properties of the fuel. An interesting comparative figure is that a plane which a few years ago required 1100 gal of fuel to carry it 2000 miles can now perform the same journey on 800 gal, or, expressed differently, a modern transport plane which could just fly from San Francisco to Cleveland without any pay load, can now fly this same journey with a 2500-lb pay load. This moreover does not take into account increase in power, which still further increases the pay-load advantage.

COMBATING THE CORROSION PROBLEM

These new developments, both in petroleum processing methods at high pressures and temperatures, and in the application of petroleum products in engines and other machinery, again open wide fields for the engineer. A few words on the industry's recent advances in combating corrosion may be in order here. In the first place, there is and will be no cure-all for corrosion in the petroleum industry. Each case must be considered separately and in detail. It is unsafe, and sometimes dangerous, to borrow a prescription because of apparent similarity of symptoms.

Efficient separation of corrosive water from crude oil has long been a problem. Chemical treating and electrical processes have been developed for this purpose and now are widely used.

Ammonia under careful pH control is used extensively for neutralization of volatile acids in distilling operations, while in furnace operations, lime, soda ash, or caustic soda is employed in the oil for acid control.

Recirculated water for condensers and coolers is often treated with inhibitors in minute concentrations to reduce scale and algae troubles and to inhibit corrosion.

The tremendous advances in recent years of metal manufacturers in developing new corrosion-resistant alloys to a commercial basis have given economic justification to many new petroleum processes and have lowered operating costs in others. A wide range of chromium steels is available now. Although the 5 per cent chromium steel continues to be very popular, increasing use is being made of 2 and 3 per cent chromium steels in less corrosive service, and of 9 per cent for more corrosive hot-oil conditions. Nickel-bearing alloys are widely used in refineries to meet special demands imposed by high temperatures and the presence of organic and mineral corrosive agents. The austenitic chrome-nickel steels are employed only when the corrosive conditions cannot be economically withstood by the lower-alloyed steels.

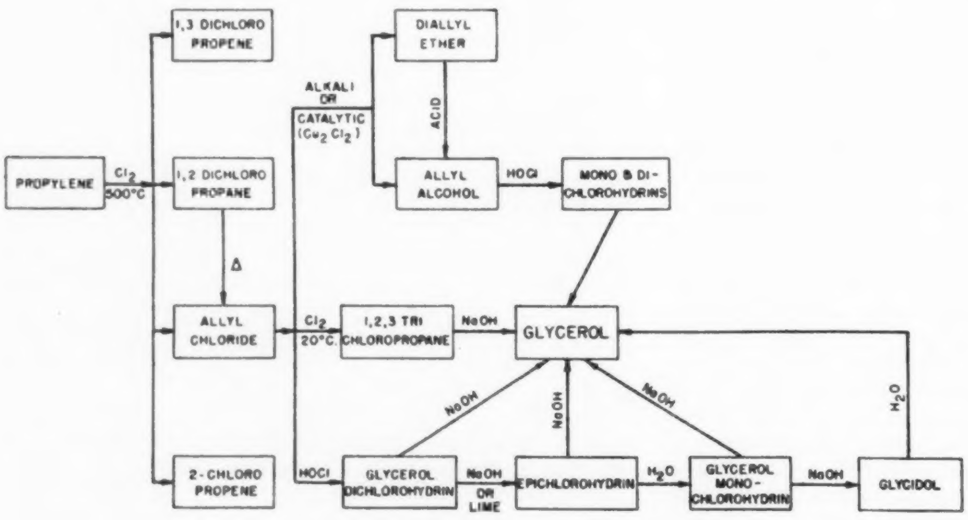


FIG. 6 GLYCEROL FROM PROPYLENE

Nickel-clad and stainless-clad steels provide immunity to corrosive depreciation of large equipment at relatively low costs. Considerable work is in progress on bimetal tubes for heat exchangers, where two alloys are needed to obtain maximum resistance to attack from the water and from the oil sides.

The developments of the last ten years in the protection of underground pipe lines from corrosion, employing electrical methods and asphalt enamels, have gone far to safeguard the enormous investment which the industry has buried.

An interesting recent advance in the refining of gasoline is the solutizer process, by which mercaptans which are sulphur compounds of a particularly odorous and corrosive type are actually removed from the gasoline instead of being converted to less odorous but still undesirable forms, as in the old doctor treating process. This process has now been worked out so thoroughly that plants may be designed for stocks they are to treat with as much engineering precision as goes into the design of fractionating towers and other standard refinery equipment. Not only does the process afford a saving in refining cost, it also makes the gasoline more susceptible to improvement in knock rating with addition of lead; and there are indications that the use of this gasoline results in a cleaner engine.

DEVELOPMENTS IN LUBRICANTS

Space does not permit more than a mention of recent advances in the field of lubricants. The story here, however, is the same as in production and gasoline manufacturing; real progress comes only with broad basic knowledge—trouble-shooting is not enough. Especially important developments in the last few years are solvent refining, and more recently the use of additives to improve oxidation resistance and lessen sludging, varnish deposition, corrosion, and wear.

Solvent extraction was the first important development. It removes a considerable proportion of the types of compounds which are responsible for sludging of oil, and improves its viscosity temperature characteristics. While this was a major advance, improved understanding of the functions of oil showed that more was needed. Oil must not only slip and seal, it must also clean and cool. The importance of the last two factors has markedly increased in the last few years with the developments of engines of high power output, which has tremendously increased the amount of waste heat to be dissipated per unit area. To keep pace with these needs, certain compounds are being added to many lubricants so that they will more readily wet the metal surfaces. In so doing they not only improve the transfer of heat from metal to oil, but also by detergent action prevent accumulation of deterioration products which would stick rings and clog oil passages. Many compounds have been proposed for such use but only after long trials have entirely satisfactory ones been evolved.

Turbine oils have also received much attention in the last few years. An especially interesting development announced only a few months ago is a turbine oil of superior stability as well as antirusting characteristics. Most oils were deficient in both of these qualities, although one or two were satisfactory in the one or the other, until very

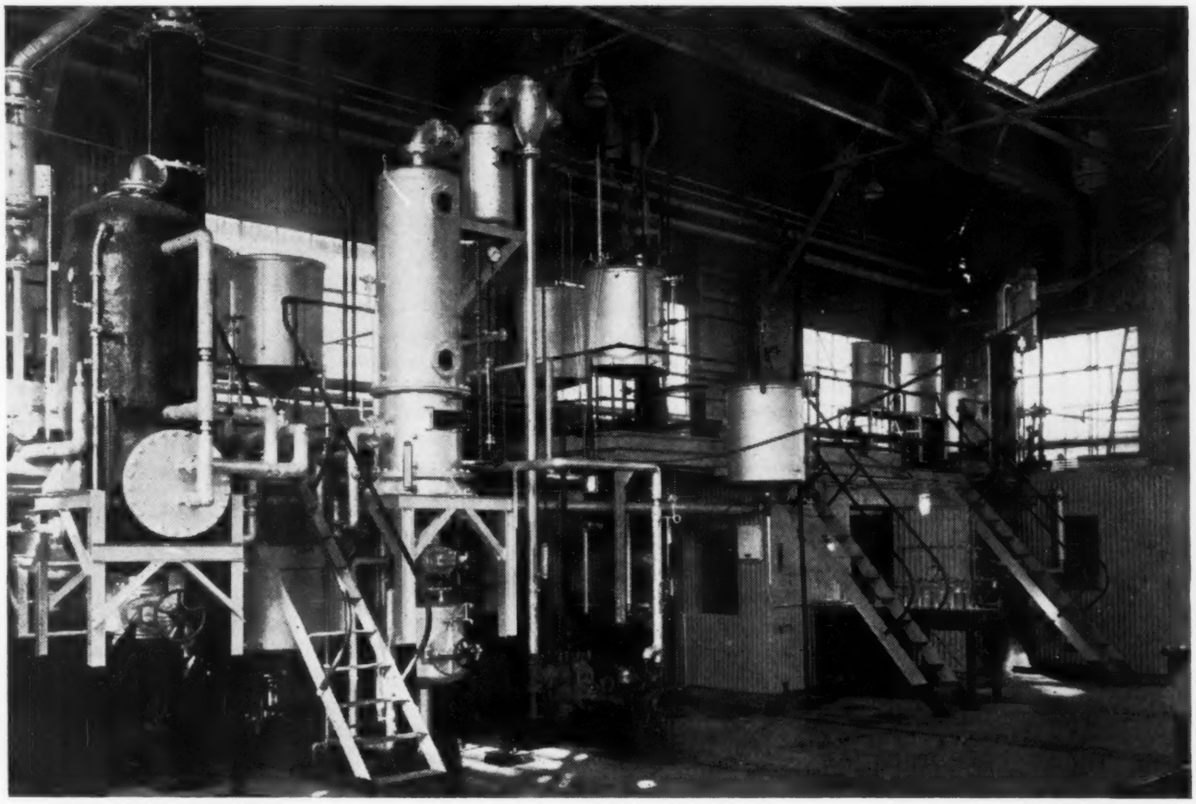


FIG. 7 PORTION OF EMERYVILLE PILOT PLANT FOR SYNTHESIS OF GLYCEROL FROM PROPYLENE

recently no oil had both. This improvement was accomplished by special processing coupled with the use of additives.

SYNTHETIC CHEMICALS

The manufacture of synthetic chemicals from petroleum and from natural gas, closely related to it, is becoming a major American industry. Petroleum is well suited as a chemical raw material. It is cheap and abundant, and contains a wide variety of chemical types which, in themselves or after cracking to simpler compounds, may be converted to derivatives of many kinds.

In the manufacture of chemicals from cracked petroleum gases the pioneers in the industry had attempted to react fairly complex mixtures of the various olefinic starting materials. This resulted in a multiplicity of main and side reaction products, with attendant difficulties of separation and purification. An important advance in manufacturing technique has been the separation of the mixture of hydrocarbons before reaction into small groups, such as C_3 (propane and propylene) or C_4 (butane and the butylenes).

Alcohols are produced from such fractions, obtained from refinery cracked gases, by absorption in sulphuric acid, followed by hydrolysis and purification. In this way isopropyl alcohol is made from propylene, secondary butyl alcohol from α- and β-butylenes, and tertiary butyl alcohol from isobutylene. Acetone is made from isopropyl alcohol, and methyl ethyl ketone from secondary butyl alcohol, by catalytic dehydrogenation. From these both esters and higher ketones and alcohols are made. Figs. 4 and 5 show a plant of Shell Chemical Company, near Los Angeles, where in 1939, 57,000,000 lb of these alcohols and ketones were made.

By treating the starting olefins with chlorine an entirely different series of products is made possible. An outstanding example is the synthesis of glycerol from propylene. Fig. 6 shows the steps by which this is achieved, starting with high-temperature chlorination to form allyl chloride, which may be converted to glycerol in several ways. Fig. 7 shows pilot-plant equipment used in the process. The process is ready for large-scale operation whenever economic conditions warrant it.

Literally hundreds of chemicals are produced on commercial or semicommercial scale from petroleum. Among them are butadiene, used for synthetic rubber; vinyl chloride and derivatives, styrene, methacrylates, and other materials, used in plastics; ethylene glycol, used as an antifreeze and as a chemical intermediate; and ammonia, used directly or in the form of sulphate as a fertilizer and for many other purposes.

The entrance of the petroleum industry into the field of synthetic chemicals has brought about important changes in its economics. Thus the guiding principle of the early petroleum chemical operations was to utilize refinery gases that otherwise would go to waste or, at most, be consumed as fuel. It would have been difficult to foresee the revolution in gasoline manufacture which was to come about as a result of one of the steps in secondary-butyl-alcohol synthesis—the step which consisted in removal of the isobutylene content of the feed by absorption in cold sulphuric acid, and recovery of the acid by heating, which polymerized the isobutylene to di-isobutylene, the source of iso-octane.

With the recognition of the possibilities of iso-octane in aviation fuel came the development of the process as a refinery operation; and it soon became a question not of finding outlets for waste products, but of supplying enough raw materials for the needs in both chemical and synthetic-gasoline fields.

Although prediction of future trends in the oil industry must be hazardous, there is no question but that chemical manufacture will play an increasingly important role, and a close relationship may be expected between refinery and chemical factory as the operations of both expand into new fields.

HOUSING FOR DEFENSE[1]

By W. RUPERT MACLAURIN

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

ACCORDING to the foreword of "Housing for Defense,"[2] the "Twentieth Century Fund began a survey of the housing situation in the United States" in March, 1940. Only a few months later the United States was engaged on a gigantic program of defense and the survey was temporarily shelved. The Trustees of the Fund decided . . . "to prepare an emergency report on housing as related to national defense."

The resulting book selects as a basis for comparison the experience of the last war. In 1916 residential construction had begun to decline—particularly building for low-income groups. The following year, when the United States entered the war, industry was concentrated in a small number of communities and the shortage of available housing facilities for defense workers became acute. During the progress of the war various government agencies attempted to deal with the emergency with only partial success. Among these the two most active were the Emergency Fleet Corporation, an agency of the Shipping Board, and the United States Housing Corporation. The former "was naturally limited in its choice of location to coastal communities and was therefore able to do little to prevent congestion of population." The latter "was created too late to exert any influence on the location of war industries." Both were so long in getting under way that they offered no real solution of the problem. The quality of the housing was good and many examples still extant are in excellent condition, but it was thought to be too costly and too good for the purpose.

According to the authors, the present situation has many more favorable factors than obtained in 1916, and the purpose of their study is "to show what kinds of problems will have to be met, and, on the basis of an appraisal of alternative policies, to suggest those most likely to succeed." In contrast to building conditions in 1916 and 1917 there are at present available adequate supplies of building materials, a sufficient labor force, and no lack of funds. Also, there has been an improvement in the technique of builders, especially in the low-priced field. The authors point out, however, that our program may very well get under way too late as in the last emergency. They stress the need of providing adequate shelter for workers in defense industries paralleling the expansion of the industries, not lagging behind.

Granted that an emergency exists and that suitable living quarters must be provided for thousands of workers who have been displaced from their usual jobs and homes and removed to other locations, there follows logically the question of who shall build the necessary houses—government agencies or private contractors? The conclusion reached in the report is that private enterprise should be able to provide most of the housing; the government cooperating "by removing obstacles that destroy initiative, by offering inducements to go ahead even in an uncertain situation, by guiding defense activity so as to avoid risks that would be too great for private enterprise, and by directing housing operations in situations where private initiative is unable to function." The need for careful planning for the future is emphasized, so that when the emergency is over there will be left factories and dwellings suitable for peacetime pursuits.

To obviate the "hazard of congestion" the authors advocate the strategic placing of industry, taking into consideration "the geographic distribution of our preparedness activities." "Selective location . . . should take into account military strategy, sources of raw materials, transportation, opportunities for storage or disposal of product, plant capacity and availability—as well as housing and labor supply. In its essence, selective location means placing defense industries—so far as other considerations permit—in localities where favorable labor and housing conditions already exist, rather than bringing labor and housing to places where the activity, more or less fortuitously, may have been located." There is already concentration of defense industries along the Atlantic Coast, some of which could be easily dispersed to other regions. This report develops in detail the theory of selective location, relating the problem to military and industrial requirements, and to existing resources in suitable communities. Need for close cooperation between the various interests involved is stressed.

There is a chapter on community problems which considers such problems as the wages and living standards of the worker and his family, housing of single persons, and the like. It is suggested that many existing buildings can be utilized and that the commuting area can be expanded. "Even the fullest and most efficient use of structures now existing or planned, however, probably will not be enough to meet the needs of a community faced with a sudden great increase in defense industry. Community growth must always ultimately call for new houses, and sudden and rapid growth means an acceleration of that demand." The main solution, then, to the shortage which already exists and which will steadily increase with the expansion of defense activities, is the building of new houses. These houses may be temporary or permanent, and the advantages and disadvantages of both types of housing are weighed. The conclusion is drawn that the only justification for temporary housing is a lowering of construction costs, and the certainty of removal of the buildings when the need for them has passed. Experience has shown that the former advantage has some validity but that "the ultimate removal of so-called 'temporary' housing is always doubtful. Once the dwellings are erected and occupied they become a part of the community." The addition of jerry building of this sort is obviously a disadvantage to any community and is likely to become the focal point of a slum section where possibly none existed previously.

It is axiomatic that the type of housing erected should be suitable to the needs of the workers and their families. This means that the houses should be low-priced, durable, capable of rapid construction. The authors again emphasize their belief that the private building industry "may go far toward meeting defense housing needs without any great necessity for unusual governmental assistance." The role of government should be advisory, supplementary, a role easily filled by the various housing agencies and by related bureaus (such as the Forest

(*Continued on page 676*)

[1] One of a series of reviews of current economic literature affecting engineering, prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of The American Society of Mechanical Engineers. Opinions expressed are those of the reviewer.

[2] "Housing for Defense: A Review of the Role of Housing in Relation to America's Defense and a Program for Action;" the Factual Findings by Miles L. Colean, the Program by the Housing Committee, The Twentieth Century Fund, Housing Committee, New York, N. Y., 1940, 198 pp.

AIMS AND OBJECTS *of*

The American Society of Mechanical Engineers

By W. F. DURAND

PAST-PRESIDENT, THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

An ORDERLY and effective approach to a study of the aims and objects of a great national body such as The American Society of Mechanical Engineers, would seem to call first for some definition of the function of the mechanical engineer, as a factor in the field of the engineer in the broader sense. I shall, however, assume this unnecessary. We may proceed, therefore, to seek some basic formulation of principle, the application of which should serve to indicate the normal and proper aims and objects to be held in view in the organization, administration, and activities of a collectivity of engineers such as those comprising The American Society of Mechanical Engineers.

As a basis for the present discussion I shall take, as the all pervading and informing purpose of such an organization, the concept of service. This immediately presents two major aspects:

1 Service to the individual member.

2 Service to the profession, with which may be included service to the public, and the world at large.

The first of these is individual; the second is distributive and carries, by implication, not only service in the domain of the mechanical engineer, but service in and to the whole domain of engineering and industrial art, and thus service to the public, to the state, and to the world at large. I further submit the proposition that the entire function and aim of the Society should be considered as comprised within these types of service, including, of course, all auxiliary and secondary functions and activities which are needed in order to make these major purposes effective.

We may now inquire in what ways the Society may or should be of service, first to the individual member. Whatever these may be in detail, the immediate purpose should obviously be to aid the individual in the performance of his particular share in the collective enterprise in which we are all engaged. What then does the individual need in order to carry on his professional work along a continuously rising gradient of quality and efficiency? Clearly no highly individualized service can be furnished; but there are certain general types of need which are common to all engineers and which admit of simple formulation. Perhaps the most important are: (1) Information; (2) stimulus; (3) opportunity; (4) judgment and skill; or perhaps we may combine these two latter and say, wisdom in the use of the means disposable for the purposes in view.

Of these, The American Society of Mechanical Engineers may hope to give active and effective service in (1) and (2)—information and stimulus. Something may be done under (3)—opportunity. The last named, wisdom, must come largely from within the individual himself, and as the result of a well-balanced mind and temperament, brought to fruition in the school of experience.

Turning now from the individual to the profession at large, we may first note, what is indeed obvious, that service to the individual is, at the same time, service to the profession at large. There are, however, many undertakings the carrying forward of which will serve to raise the level of professional practice in some broad domain of the field, rather than benefit the individual as such, and which may, therefore, be viewed as service to the profession at large rather than to the individual.

A.S.M.E. ORGANIZATION

We shall now turn to the organization and activities of the Society and test these with reference to the character of service which they are calculated to render, either to the individual member or to the profession at large.

First as to organization. We find here the membership classified and organized according to three modes: (*a*) According to age and experience; (*b*) according to special professional interest (professional divisions); (*c*) according to geographical location (local sections).

The organization of the Society into various age classes of membership may be justified first on economic grounds. For the funds with which to carry on its various activities, the Society must depend, in large part, on dues collected from its membership, and it is more equitable, and presumably more effective, to assess these dues graduated according to age and experience rather than to attempt a single fee for all members, regardless of presumptive ability to pay.

A further justification may be noted under the general head of stimulus—in particular, stimulus to the younger members who, entering in the lower ranks of membership, have before them the pleasurable anticipation of increased rank and prestige with growth in years and experience.

I see no valid reason for suggesting change in the principle of a stratification of membership. The reasons for this type of organization appear sound and the results satisfactory.

The entire question of how much the membership should be taxed in order to secure the largest practicable return for sustaining the activities of the Society is one which must be considered on the basis of broad principles such as the following:

1 The income from the Society from all sources can never be made to equal the cost of what appear to be its justifiable and proper activities.

2 There are broadly only two major sources of income—(*a*) from the membership, and (*b*) from publications (chiefly advertising).

3 The activities of the Society must obviously be adjusted to this total income whatever it may be.

4 The amount that the membership will be willing to contribute will depend on the economic conditions for the time being, and generally on the level of such dues in other similar organizations.

The question of dues was considered at length in the Wescott report of 1936-1937, and after careful analysis a recommendation of no change was made—wisely as I believe the event has proved.

Again the growth of the Society in the sixty years of its life has carried it geographically to all parts of the United States.

Prepared at the request of the Council of The American Society of Mechanical Engineers and ordered printed. Comments are solicited for publication in future issues.—Editor.

It has also expanded enormously in scope, until the activity of the individual member is limited, as a rule, to only a small part of the wide interests which the Society as a whole seeks to serve. These expansions have led to stratification in two modes, one geographical and one professional. This has given rise to the organization of local sections and of professional divisions.

Broadly, the Society aids these organizations in carrying on their professional life and activities, the latter consisting chiefly in the holding of meetings for the reading and discussion of technical papers. What the national meetings do for the Society at large, these smaller meetings do for the smaller groups involved. In a particular sense, the local-section meeting brings the Society to the local resident. The more recent policy of the Society, of holding general meetings in large centers of population and industry throughout the country, has done much to take the Society into the field and to the distant member; but, to a considerable fraction of this distant membership, the local section and its activities must still stand, in large degree, for the life and activities of the parent body.

In a somewhat different way, the meetings of the professional divisions meet the special interests of the individual. At a general meeting, his own special interests may be only poorly represented, either in papers or professional activity otherwise. If his special interests are to be served, it must be through a series of meetings where the subject matter is single valued and responsive to his own special interest.

A.S.M.E. ACTIVITIES

Turning now to the direct activities of the Society, these may be classified as follows:

1 The holding of meetings or conventions of the Society as a whole.

2 Granting of subsidies or aid for the holding of divisional or local-section meetings.

3 Publications.

4 Participation with other organizations or in joint undertakings.

5 Organization of committees for a wide variety of purposes but, for the most part, having relation to codes and standards.

6 Aids to research through bringing together the man and the problem or in finding sources of funds for carrying on the work.

7 Income-producing activities, chiefly advertising carried in serial publications and "Mechanical Catalog."

8 To these may be added the necessary internal activities for the operation of the Society as such, comprising a number of standing and special committees, office organization, and routine administration.

We may now apply the test of "service" to these various activities.

First, the holding of national meetings of the Society as a whole. Such meetings bring together members of the Society from all parts of the country, give opportunity of coming into early contact with the latest thought or achievement in the various fields of work of the mechanical engineer, give opportunity for personal contact between the membership at large and the leaders in the profession, and thus, in high degree, answer to the criteria of furnishing information and stimulus.

Second, encouragement and financial aid in the holding of meetings of the professional divisions and the local sections. If the general policy of the twofold mode of stratification is wise in itself, the active support of the work of these two modes is certainly justified—at least as judged by the general criterion of service to the member and through him to the profession, to the public, and to the world at large.

PUBLICATIONS

In the field of technical publication the Society has, for many years, taken a leading position among like engineering organizations. It is now publishing serially, MECHANICAL ENGINEERING and Transactions, including the *Journal of Applied Mechanics* as representing the professional division of that title. It also publishes membership lists (biannually) and society records (annually).

In addition, it publishes from time to time, manuals of craft technology, codes of design and construction, codes of testing, and codes of safety; likewise many smaller publications, each one dealing with some phase of mechanical practice. Following is an inadequate summary of the 1940 list, with the number of separate publications following each title:

Manuals (2), safety codes (5), standards in machine-shop practice (36), piping standards (15), symbols and abbreviations (15), boiler code (11), power test codes (16), auxiliary sections to power test codes (23), standards under present development (21), test codes under present development (7), with auxiliary sections (6), bibliographies (8), biographies of eminent members of the society (6), research publications (11).

And finally mention must be made of a number of publications to the production of which the Society has contributed in some form or degree, such as the monumental work on hydraulic structures by Schoklitsch; "Hydraulic Laboratory Practice;" the "General Discussion on Lubrication;" research work on the properties of steam; and others.

While naturally there will be great variability in the value of these various publications and in their significance to the individual engineer, the type of activity is certainly one which fully justifies itself both as to service to the individual member, and as service to the profession at large.

WORK OF THE SOCIETY THROUGH COMMITTEES

The vastly complicated mesh of activities, fostered and carried through by the Society, obviously calls for the organization of a manifold of small organizations or committees, each one charged with some one particular phase of this great beehive of activity. Three types of committee activity may be recognized:

1 Activities relating to the daily business and orderly life of the Society as such.

2 Activities relating to some phase of technical work fostered or supervised by the Society.

3 Participation with representatives of other like organizations for the purpose of carrying forward some common undertaking.

Under 1, there are 16 standing committees, dealing with such subjects as: Finance, Meetings and Program, Publications, Admissions, Research, Standardization, etc. The need of committees in this category would appear to be above question.

Under 2, the Society finds perhaps its most widely diversified field of activity.

In some cases, the A.S.M.E. committee is the direct sponsor for the undertaking; in others it has membership on joint committees or on committees dealing with projects sponsored by other organizations. The 1940 list of such activities shows for research, 17 committees, with membership on 17 other miscellaneous research committees, and for standardization, 31 committees with 37 representatives on 26 other committees dealing with like projects.

Under 3, there are many activities which bear relation to the advancement of the engineering profession as a whole rather than to the special interests of any one division of the field. Participation in such activities through some form of joint committee organization constitutes an important part of the work of our Society. Such are participation in the work of the

United Engineering Trustees, maintenance of the Engineering Societies Library, Engineering Societies Personnel Service, Inc., International Electrotechnical Commission, various awards, medals, and the like.

With such a vast complex of committee activity, there will certainly be inequality as between the results accomplished by one committee and those by another. Mistakes will be made in the selection of subjects and in committee personnel. It is quite possible that some of these committees or subcommittees might be dispensed with, without detriment of the work of the Society. It is equally possible, or probable, that new committees should be formed and new lines of activity undertaken. The whole subject of committee organization and activity might well be made the subject of examination by a special committee appointed for the purpose. However, any competent judgment regarding the over-all results achieved during the life of the Society by activities of this character cannot but justify these activities in themselves as most eminently qualifying under the broad head of service—service to the profession at large, to the membership, and, incidentally, to the individual members concerned.

AIDS TO RESEARCH

The principle underlying this phase of Society activity should need no defense. Research lies at the foundation of progress. The Society can do little in the way of direct financial support of research. It can and does, however, aid research by bringing together the man and the problem and aids in finding financial support for the work. This activity is carried out under the standing Committee on Research, working through small subcommittees, each one charged with more direct supervision of the actual work. A long list of publications indicates the results of activities under this head.

The remarks made regarding inequality of results applies here also. Projects may be unwisely chosen, errors in the selection of personnel may be made; but the basic principle of "aid to research" cannot be questioned as a suitable and indeed a needful line of activity for the Society. The long list of accomplishments in this field, as known to the profession at large and as partially indicated in the list of "publications," is impressive and surely represents a leading contribution to the advance of the engineering profession at large.

INCOME-PRODUCING ACTIVITIES

If the Society is to live and carry on its work, it must have income. It can never have enough to meet the opportunities for service which lie in its path. It has, apparently, only two sources of income—annual dues and publications. Analysis of income and expenditures for the year 1938-1939 shows that the average income from dues was $14.55 per member, while the total expenditure per member was $28.14. For the $14.55 received per member, $15.60 per member was returned to him in the way of publications, to say nothing of the many other modes of Society activity from which he would profit either personally or by way of general advance of the profession at large.

If the basic purposes of the Society are sound and if its activities properly qualify under the head of Service, then the policy of augmenting income by other dignified and suitable means would appear to find justification.

Under the head of "dignified and suitable" means, there appears little outside of advertising carried in technical publications which could be considered as qualifying. Under this head of advertising matter it is, of course, of vital importance to the Society that such material be subjected to the most careful scrutiny as to its character, so as to insure against any hazard that the Society might appear to support or indorse claims of an extravagant or unsuitable character. The record of our publications I believe to be clear in this respect.

SERVICE TO MEMBERS

This survey of the activities of the A.S.M.E. appears to reveal none which fails to qualify under the general head of service. There remains, however, the question of relative values. There must be differences here. Without attempting analysis in detail, it may be possible to reach a judgment regarding the two main types—service to the individual and service to the profession and the world at large. In order, therefore, to form a focus for discussion, I shall lay down the proposal that the present interests of the Society would be better served by increasing the service to the membership, at the cost of some reduction in the service to the profession and to the world at large.

I shall not attempt to argue out this proposal in great detail. It is possible, however, to lay down certain general features, each one of which may be suggestive of grounds for a judgment as to the relative value of these two major types of service. Thus:

1 The Society is a voluntary association of individuals. Should not its first obligation be toward its membership rather than toward the profession more broadly, of which its members form a part?

2 Service to the individual, moreover, is service to the procession, since the latter is a multiple of the former.

3 Service to the profession (codes, standardization, research, etc.) furnishes a less direct service to the membership than service to the latter direct.

4 For a voluntary organization such as ours, there is nothing more fundamentally essential than an enthusiastic and reasonably well satisfied membership. Our activities depend to an enormous extent on free service by the membership, and beyond that, on financial support by way of dues. Nothing can take the place of an aggressive, enthusiastic, wholly loyal membership.

5 To obtain and hold such a membership, is it not worth while to make the individual member feel that the promotion of his professional welfare is at least one of the chief aims and objects of the Society?

If, then, it be assumed that the best interests of the Society would be better served by more of direct service to the membership and less to the profession at large, there still remains the question of what form this additional service to the membership should take, and how far it should go? And again, of the extent to which service to the profession at large might or should be reduced.

As a basis for an answer to the question of the best form which this increased membership service might take, I shall lay down the proposal that the best service to the member is that which will best stimulate and encourage him to do something for himself and for the Society of which he is a part, or for that part of the Society with which he is in most immediate contact. This points immediately to the local sections and to the professional divisions.

IMPORTANCE OF THE LOCAL SECTION

As between these two groupings of our membership, I shall lay down the further proposal that the greater present good will be realized by stimulation of the local sections to greater activity than by an attempt similarly to stimulate the activities of the professional divisions. This does not imply any question as to the existence of the professional divisions or their activities. On the contrary, the plan of such subdivision is most admirable since it gives us now 17 smaller societies within the parent body, each with a well-defined field of special interest.

However, as regards membership, a professional division is spread nation-wide and cannot have the coherence and sense of solidarity which naturally pertains to a local section.

The local section is, for the most part, a relatively small coherent geographical group. A group in which there is likely to be a large degree of personal friendship and acquaintance among its members; a group which normally should be well fitted for teamwork in Society affairs. Furthermore, for its particular locality the local section *is* the A.S.M.E. It is all that much of the general public may know or see of our Society or of its activities. I hold that in no way could the loyalty and enthusiasm of the individual member for the Society be more effectively enlivened and assured than by stimulating and encouraging him to greater activity as a member of his own local section. And surely no one can question the good effect on the Society, in its larger aspects, of a pronounced stimulation in the activities of these local groups.

Another question regarding local sections presses for consideration. These sections show necessarily great variation in numerical strength—from 3316 for the Metropolitan Section to 20 for the Memphis Section, with corresponding variation in professional strength and activity. Of the 71 sections listed for 1940, 39, or 55 per cent, have less than 100 members and 13, or 18 per cent, less than 50 members. It is possible, even probable, that the professional activities of some of these weaker sections hardly justify their continuance. And yet they are our outposts on the frontier. They represent us in the technically and industrially less developed sections of our country. What can be done for or with these sections? Can they be strengthened, stimulated, and encouraged to such greater degree of professional activity as better to justify their continued life? Or should perhaps some of them be discontinued or merged with other adjacent sections? In my judgment, and with special reference to our continued life in the South and West, these are questions of great importance, and I would submit as a proposal, that all practical means of encouragement, stimulus, and aid be exhausted before discontinuance or merger is decided upon.

An important question remains. If the activities of the local section are to be increased, in what might these increased activities consist? To this there is no single answer. It will depend on local conditions, on personalities, and on many factors which cannot be evaluated as terms in a single equation. This again might well be made the subject of special study by an appropriate committee which should include representation of the locality concerned.

It is assumed that any such redistribution of activities as suggested would, of necessity, require a corresponding redistribution of funds. With a total effort determined by our income, an increase in one direction must imply a decrease in another. What activities, then, should be decreased? I have taken space here, only to suggest the broad domain of service to the profession at large. In what particular way, I shall not attempt to specify. That again should be made the subject of committee study.

Another feature of our policy meriting notice is that of visitations to local sections. Present practice provides for such visitation, but limited by budget allotments and by the number of individuals available. I submit as a proposal that the amount of this local visitation should be increased with, of course, a corresponding increase in the budget allotment. And further, such visitation should be directed to the more remote and, as they may be termed, "underprivileged" sections. There can be, in my judgment, no more effective way of increasing in the mind of the remote local member his sense of solidarity with the great national organization of which he forms a part.

WHAT IS THE ESSENTIAL FIELD OF OUR SOCIETY?

Among the complex of questions which press for consideration, perhaps none lies closer to the effectiveness of our professional life as a leader in the technical and industrial life of our country, than that of the adequacy of our occupancy of our chosen field. This calls for a definition of the extent of our field, and this is not easy. We shall have to admit, I think, that in the past the Society has not fully occupied its field, since there have sprung up, during the last thirty or forty years, a number of national organizations each one of which represents a line of interest which may fairly be considered as lying within the broad domain of what may properly be called mechanical engineering, for example, heating and ventilation, refrigeration, internal-combustion engines, welding, and industrial management.

We may take it for granted, I think, that there is no likelihood of a return of these groups, or of any of them, to the fold of the A.S.M.E. The whole tendency of modern evolution in these matters appears to be distinctly centrifugal—subdivision and separation rather than amalgamation and union. Confronted with this situation it does seem clear, however, that we should, at least, clearly visualize and define our own present field and then so conduct our affairs as to adequately occupy that field. And by "adequately" I mean to the degree which will serve to hold the loyalty of our present membership and forestall agitation with reference to the splitting off of groups with some special line of interest which they may feel does not receive adequate recognition in the management of the Society. Does this situation call for the organization of a committee to study our present activities and to answer the two questions:

What is the essential field of our Society?

Are we adequately occupying this field?

IMPORTANCE OF SERVING YOUNG MEN

Another phase of the Society's interests deserves an emphatic word. The leadership in our Society 10, 20, and 30 years hence will devolve, in primary degree, upon the present student and junior members of today. The Society must live, it must continue to grow, and the future of a few decades hence will depend on what we are doing today for those who, in the years to come must assume the leadership and direction of our organization. No one of our problems is more important than that of insuring a continued sustaining inflow of young personnel into the Society and of giving to them, in the early years of their membership, such opportunity, guidance, stimulus, and recognition as will serve to fit them for the responsibilities which must be theirs a few years later.

The direction of our Society has not been blind to this obligation. Student branches, competition in the preparation of papers, and other junior- and student-member activities are now in effect. Can these means be improved? Can other means of stimulus and opportunity be brought to bear on this younger section of our Society? I submit that this entire question might well be made the subject of special inquiry by a committee appointed for the purpose.

Doubtless there are other matters which merit notice under the general heading of the title of this paper—matters of organization or of activities. I have, by no means, exhausted the field, but the points touched on in the present paper may serve as starting points for discussion, and in the light of further search we may be able to reach a clearer vision of our place as a Society of Engineers in helping to carry on this cooperative enterprise of civilization, and thus more adequately justify our assumption of a proprietary claim over this particular domain of human activity which we seem to have staked out as our own.

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context and credit to original sources is given.

Railroads Need College Men

THE YALE SCIENTIFIC MAGAZINE

IN THIS age of increasing demand for specific education in every field, says R. C. Morse, vice-president, Pennsylvania Railroad, in the summer 1941 issue of *The Yale Scientific Magazine*, railroad work too reflects the contemporary bias toward the young man with college preparation. The quest for leaders, says Mr. Morse, is more active today than ever before in our industrial history. There is a scarcity of men capable of serving as leaders. The difficulty is to find men who can cope successfully with the many problems with which business is confronted today. In the search for men of leadership there must be an orderly and methodical system for the educational development and assignment of executive personnel. Nothing contributes more to give the college man the proper attitude toward his first years in business than the removal from the college curriculum of those courses which tend to make him think he knows how business is managed.

The problem of the transition of the college man from his college activities to business activities is not to be solved merely through the development of a minor technique of recruiting college men for business, but rather by a much closer knitting of the educational values that lie in the college and the training values that lie in business activity. Join these two values into a unified program and the problem of transition will have been solved.

The graduate at the end of his collegiate education should have acquired a greater capacity to influence the behavior of other men, and to deal with other men. He should have substantially greater ability to approach the solution of business problems with the use of tools of scientific method and have a better grasp of ways of arriving at principles of business administration. He should also have an understanding of the social, economic, and public implications, and relationships of business activity. What is of permanent value is the acquisition of a technique of investigation as applied in management—the impulse to verify facts to challenge mere gossip and impressions, the power to use statistical methods and to handle historical evidence. To these needs the university curriculum may contribute.

Particularly from the standpoint of the railroads the student should be afforded opportunity to observe the application of methods of study as applied in the railroad industry, thus bringing clearly to his mind the fundamental importance of the scientific approach to their solution. Any man entering railroad service cannot hope to receive recognition in an official way during the first few years of his service. In most cases it takes at least that long to acquire the necessary detail railroad education to fit him for even a minor official position.

The railroads desire college men in their service, and any graduate who is willing to start in upon graduation and who approaches the field with a willingness to go through with a number of years of hard work will find that the rewards at the end of that period are as great as they are in any other industry.

Uses for Silver

AMERICAN SILVER PRODUCERS' RESEARCH PROJECT

THE American Silver Producers' Research Project, sponsored by several of the leading silver-producing companies in the United States, has completed a year of activity at the Bridgeport plant of Handy & Harman, according to a progress report recently released. The project, formerly located at the Na-

ROW OF 75-MM PACK HOWITZERS BEING ASSEMBLED AT THE GENERAL ELECTRIC PLANT AT ERIE, PA.

(These guns are being produced largely on machines previously used for making electric motors for streetcars and locomotives. Originally designed for mule transport, howitzers of this type are now towed on pneumatic tires by motorized troops. Some batteries have been carried by airplanes in maneuvers. The weapon hurls a 15-lb shell nearly three inches in diameter more than five miles. Complete interchangeability of parts and close manufacturing tolerances are demanded. Assembly-line production has been under way for some months with the men who formerly made motors now making howitzers.)

tional Bureau of Standards, Washington, D. C., was reorganized June 1, 1940, and the research program and activities were transferred to the laboratories of Handy & Harman.

The field of electroplated coatings continues to show promise as an outlet for silver and the project's pilot plating plant has been kept busy recently plating drums, pails, and cans. For the general run of containers the additional cost of silver plating is not warranted, but this is not true of packages for some specialized products. Silver-lined containers are being seriously considered and tested for packaging corrosive materials because the corrosion resistance of other metals and lacquers is not adequate.

In recent months the scarcity of many base metals has focused attention on the use of silver as a substitute for aluminum, nickel, and tin. In places where sheet or foil aluminum has been used, for its corrosion resistance or high reflectivity, it is apparent that silver plating on available metals can be substituted since it possesses these qualities, for most purposes, to an even better degree than aluminum. Silver electrodeposits are being investigated as a substitute for nickel, as an undercoating for chrome plating. Experiments are under way to determine what advantages may be derived from the use of a corrosion-resistant electroplate of silver followed by a hard, wear-resistant chromium deposit.

Extruded tubing made from an alloy of 3.5 per cent silver and 96.5 per cent tin developed a bursting strength of 2500 psi or almost double that of pure tin. Threaded joints made with the alloy had a tensile strength 25 per cent greater than joints made with pure tin tubing. For certain installations it would seem feasible to use threaded connections in distilled-water lines if the tubing were made of the silver-tin alloy.

Interest continues in the possibilities of using lead-silver solders in place of the standard lead-tin alloys in automatic can-making machines. A large saving in the use of the strategic metal tin would result from this substitution. The $2^1/_2$ per cent silver-lead alloy is cheaper than the standard 50-50 solder and joints equally as satisfactory can be obtained. Many of the larger can manufacturers are actually carrying on experiments with these alloys to obtain data on actual operating conditions and service tests. Both the 3.5 per cent silver and 5 per cent silver-tin alloys are also finding applications as solders.

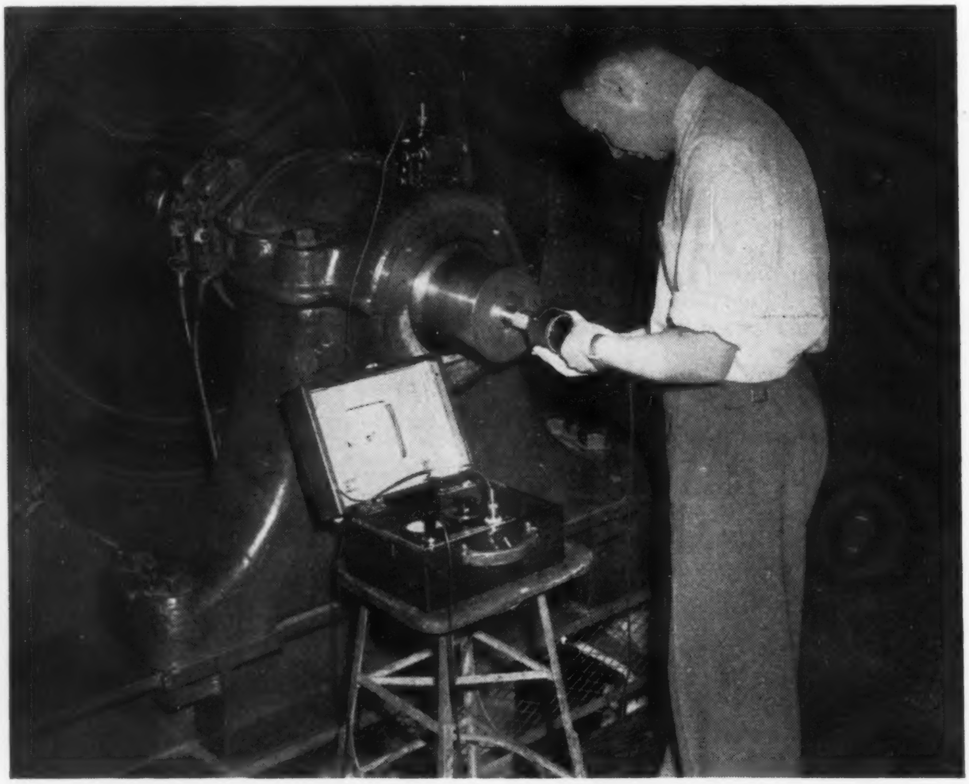
The Silver Project's Fellowship at Lehigh University has continued with the corrosion studies of silver. The corrosion tests made include not only a study of different chemicals but also a study of a large number of different commercial products which may be manufactured in silver equipment or packaged in silver containers.

More recently a study has been started on the corrosion of silver-to-silver joints made with different silver brazing alloys. This is of particular interest in connection with the manufacture of silver-lined chemical equipment.

Exhaust Efflux Propulsion

FLIGHT

IN A recent paper entitled "Technical Progress in Aviation," presented at a meeting of Section M (Engineering) of the



PORTABLE BALANCING EQUIPMENT

(Dynamic-balancing equipment recently introduced by the General Electric Company makes correction of unbalance of rotating machinery simpler, faster, and more complete than was possible with previous methods, it is claimed. The balancing equipment consists of three principal parts: a sine-wave alternator, a vibration velocity unit, and an indicating unit and its associated circuits, all fitted in a handy carrying case. It may be used during initial manufacture or installation of a rotor, after subsequent servicing, or to correct unbalance caused by pitting or corrosion. Rotors may be checked with the device while running in their own or in substitute bearings.)

American Association for the Advancement of Science, and published in MECHANICAL ENGINEERING, Feb., 1941, p. 95, J. C. Hunsaker in discussing the use of exhaust gases for jet propulsion of airplanes says that it is estimated that as much as a 10 per cent gain in effective thrust of the engine can be obtained in this way from the exhaust.

Confirmation of this estimate is contained in an article by

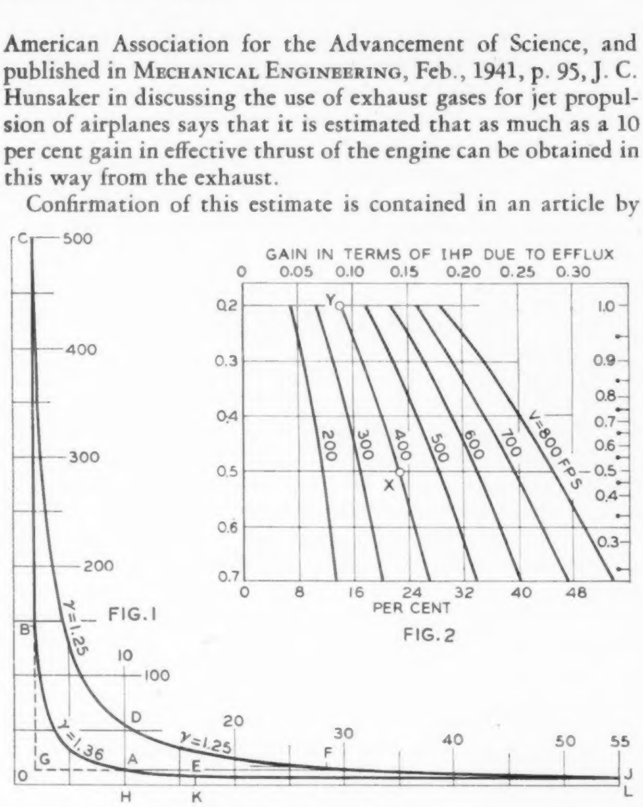


FIG. 1 THEORETICAL INDICATOR DIAGRAM UNDER SUPERCOMPRESSION "BOOST" RATIO 2 TO 1

(Expansion shown carried down to lower atmospheric level, line *EJ*, being 6.5 psi. The upper level, 13 psi, is taken as induction pressure at point *A* as representing ground-level conditions.)

FIG. 2 GRAPHS SHOWING "GAIN" IN TERMS OF INDICATED HORSEPOWER (UPPER SCALE) AND IN TERMS OF THRUST HORSEPOWER (LOWER SCALE)

(It is assumed that there is no loss of energy in the act of ejection—jet friction, etc. The graphs are plotted for flight speeds ranging from 200 fps to 800 fps. The scale on the right hand gives the inverse of the supercompression ratio; thus the mark at 0.25 near the bottom of the diagram corresponds to a supercharge ratio = 4 to 1. The scale on the left hand gives the relation of the "tail" area to the area of the diagram proper, namely *ABCD*, Fig. 1.)

F. W. Lanchester entitled "Exhaust Efflux Propulsion," published in *Flight* for April 17, 1941, pp. 285–286. Four previous articles of this series appeared in *Flight* for Nov. 16 and 23, and Dec. 7 and 14, 1939. In this final analysis the author takes up the effect of supercharging and gives a generalized solution of the problem.

Referring to Fig. 1, for an engine *without supercharge* the area *ADF* represents the work available in the "tail" in terms of the area *ABCD* which represents the work done in the motor cylinder. The graph *DF* represents the continued expansion of the charge to atmosphere, when normally it would be expelled after release at *D* at about 40 psi above atmosphere. Those pioneers of bygone days who attempted the compounding of a gas engine, envisaged this continued expansion as taking place in a low-pressure cylinder. The modern idea is to make use of this energy in a quite different manner, namely, by imparting a high efflux velocity to the exhaust, which, directed backward, acts after the manner of a reaction turbine, and supplies a supplementary force of propulsion. The relation between the areas *ADF* and *ABCD* does not much depend upon the actual pressure of the atmosphere in which the engine is put to work, provided there is no supercharge, and as an average figure (at full open throttle), this relation, in the previous articles, was taken to be 20 per cent, which is never far from the truth. In Fig. 1 the relation (calculated) is 19.5 per cent.

It is hardly necessary to state that when there is supercharge this average figure will not apply, and the relation will in every case need to be calculated according to the degree of "boost" specified. To take an example, let us suppose that an airplane designed to operate at an altitude of from 20,000 to 25,000 feet, where the pressure is about half that at sea level, be furnished with a compressor designed to give an increase in the relation of 1 to 2, that is to enable the engine to give its normal low-level performance. The expansion may now be carried much further. Thus, the expansion will not cease at *F* but will continue to a point *J*, and the "tail" of the diagram will comprise the area *JADJ*, which is calculated as the area *LHDJ* − (*KHAE* + *LKEJ*).

The significant result is that in this particular case the energy available in the "tail" of the diagram *JADJ* is almost exactly 50 per cent of that in the diagram *ABCD*. This takes the place of the 20 per cent ratio hitherto assumed as applying to an engine without supercompression.

Then taking the remaining data as previously, the gain in terms of engine indicated horsepower is 14 per cent compared to 8.8 per cent before. These two points are represented by the letters *X* and *Y* in Fig. 2, and do not allow for mechanical losses. If a mechanical efficiency of efflux of 0.50 is assumed then the values of Fig. 2 need to be multiplied by $\sqrt{0.50}$ = 0.71, and the gains reduce to 10 and 6.3 per cent in terms of indicated horsepower for the points *X* and *Y*. Fig. 2 illustrates graphically how the effect of the jet increases with speed of flight and with degree of supercharge.

Explosive Rivets

THE DU PONT MAGAZINE

PREVIOUSLY mentioned in this section in the October, 1938, issue, explosive rivets have since undergone over two years of intensive development and are now being manufactured in commercial quantities to help speed the production of American aircraft, according to an article by D. L. Lewis, Jr., in the midsummer issue of *The Du Pont Magazine*.

The explosive rivet is used to fasten together metal plates which are accessible from only one side. A charge of high explosive held in a cavity in the end of the shank is exploded by the heat of an electric heating gun applied to the head. The explosion expands the charged end of the shank, forming a "blind" head and setting the rivet.

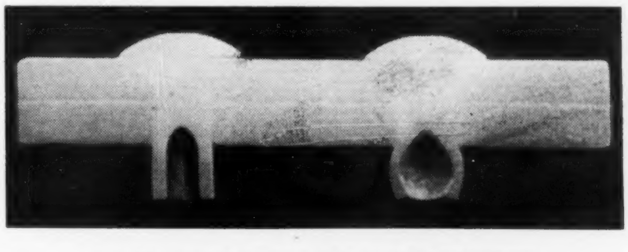


FIG. 3 RIVET BEFORE AND AFTER EXPANSION

In the largest bombers there may be as many as 10,000 rivets that are accessible only from one side. With the best mechanical methods now employed a skilled workman can set from two to four blind fasteners a minute, after they have been placed in the holes. This troublesome operation has presented one of the worst bottlenecks in the mass production of planes.

The new explosive rivets can be installed by one workman at from 15 to 20 a minute after they are in place, and the rivets themselves weigh only about one fourth as much as generally used blind fasteners of mechanical design.

Fig. 3 shows a rivet before and after expansion. Owing to the nature of the explosive no wadding or confinement of the charge is necessary. Dimensional control and regulation of the charge are so uniform that the expansion is kept within a range of 0.020 in.

The aluminum-alloy rivets are installed in the age-hardened condition and do not require refrigeration after heat-treatment as with conventional rivets of the same alloy. In shear and tension the new rivets develop values which approximate those of driven rivets. They are safe and may be used without fear of serious injury. Safety tests indicate that they will not detonate in mass and are quite insensitive to shock or friction. Several million of these rivets have been used in American airplanes that are now in service.

"Mercurystat"

ELECTRICAL ENGINEERING

A MULTIPLE-contact mercury switch that can be operated by a small force and travel is described by K. A. Oplinger of the Westinghouse Electric and Manufacturing Company in the August issue of *Electrical Engineering*. The construction is shown by the schematic drawing, Fig. 4. Small flat terminals, each having a central hole, are assembled as shown with an insulating spacer between each pair of terminals. A stainless-steel bellows with a plug to reduce the volume of mercury is attached to the bottom of the terminal assembly. Displacement of the bellows raises and lowers a central mercury column which shorts out, or cuts in, sections of an external resistor connected to the ends of the terminals. An arc-reducing gas such as hydrogen is used to protect the contacts.

Only a small displacement of the bellows (0.015 in.) is required to short out all terminals of a 40-step Mercurystat, and when driven by an electromagnetic driver the full mercury column can be raised by a change of 0.05 watt in the coil driving the bellows. Change in power controlled may be five kilowatts so that the power amplification is 100,000.

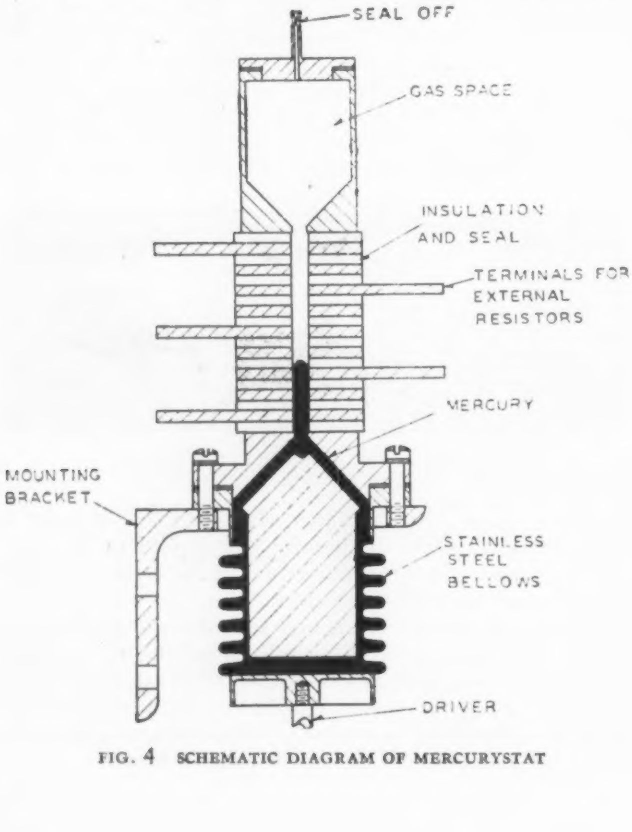


FIG. 4 SCHEMATIC DIAGRAM OF MERCURYSTAT

Life tests made with a unit operating in a 220-volt d-c circuit and varying the current from 12 to 30 amperes showed practically no sign of contact wear after 5,000,000 cycles of operation.

S.A.E. Steels

S.A.E. JOURNAL

THE 1941 S.A.E. Handbook just published contains comprehensive revisions of S.A.E. steel specifications. The revised standards provide for 72 carbon and alloy grades and 12 corrosion- and heat-resisting alloys—a total of 84 in place of the 109 standard steels previously listed. Announcement of the new handbook was made in the June issue of the *S.A.E. Journal*.

The revised S.A.E. steel specifications have been listed under two headings: "Primary" and "Secondary." Primary steels are those used in substantial quantities; secondary steels are those considered essential by certain users, but not used extensively. This listing will indicate to users the limited-source materials and encourage them, where practicable, to adopt a primary steel for their purpose.

Radiolocation

FLIGHT

THE first official intimation of a radio echo device for the location of enemy aircraft was a mention by Mr. Attlee in the House of Commons in June, according to *Flight* for June 26, 1941. Later this was amplified at a press conference by Air Chief Marshal Sir Philip Joubert, who recently took over Coastal Command.

There is, *Flight* continues, no secret about the radio phenomenon which is employed; it is merely the property of reflection, or echo, of radio waves by any solid object. The secrets lie in the operational uses of devices employing the phenomenon. Sir Philip Joubert, in his address to the press, would not commit himself beyond the following statement—"Ether waves, which of course are unaffected by darkness or fog, are constantly sent out to act as scouts far beyond the limits of our shores. Day and night distant outposts of the ether are perpetually 'manned,' so to speak, by wireless electronic watchmen ever ready to flash us tidings of the enemy's approach with the speed of light itself.

"Radiolocation makes it largely unnecessary to maintain standing patrols, and so it has saved the country an immense expenditure on petrol, engines, and wear and tear of aircraft. It has also obviated the tremendous strain on personnel which otherwise would have been unavoidable.

"In the Battle of Britain the advantages of radiolocation were even more apparent. Our sorely overworked fighters had no need to maintain standing patrols. They could rely on the vast radiolocator system to tell them in plenty of time when the enemy were coming and from what direction. This was of such incalculable help to them that independent observers from the Dominions have stated categorically that the Battle of Britain was won by the fighters of the Royal Air Force and radiolocation."

Electrical Engine Indicator

PHILIPS TECHNICAL REVIEW

THE construction of "An Electrical Pressure Indicator for Internal-Combustion Engines" is described by P. J. Hagendoorn and M. F. Reynst in the December, 1940, issue of *Philips Technical Review*, and "The Recording of Diagrams With the Electrical Pressure Indicator," by the same authors appears in the January, 1941, issue.

The apparatus employs a cathode-ray tube to indicate the pressure variations, and a device similar to a condenser microphone for the pickup. A membrane *M*, Fig. 5, is set into the wall of the cylinder and this, together with a fixed counter electrode *T*, forms a condenser, the capacity of which varies with the pressure in the cylinder. This condenser is part of a balanced bridge circuit which is fed with a high-frequency voltage (450 cycles per sec). When the capacity of the membrane condenser is varied by the pressure, the high-frequency voltage taken from the bridge is modulated by these variations. After amplification and rectification the deflection voltage is obtained for the vertically deflecting plates of the cathode-ray tube. The horizontal deflection can be made proportional to time or to the displacement of the piston. Calibration of the instrument is obtained by connecting it to a cylinder of compressed gas and reading the pressure with a manometer. Calibration is only valid for a given sensitivity of the amplifier and a given amplitude of the high-frequency voltage supplied to the bridge.

In the recording of diagrams with such an apparatus it will be realized that it is simpler to produce a pressure-time diagram than one of pressure-volume, as for the former it is only necessary to employ a conventional saw-tooth sweep voltage for the horizontal deflection. Figs. 6 to 9, inclusive, are examples of actual pressure-time diagrams.

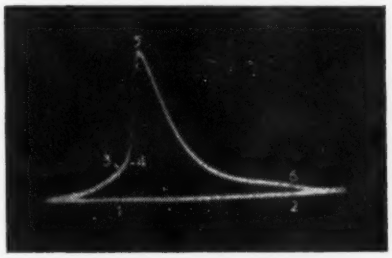


FIG. 6 PRESSURE-TIME DIAGRAM OF A FOUR-STROKE ENGINE

(The time base is equal to one revolution of the crankshaft.)

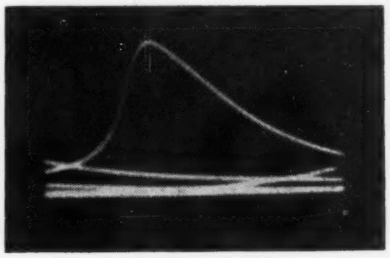


FIG. 7 SAME DIAGRAM AS FIG. 6 ON LARGER SCALE

(The time base is equal to one-half revolution.)

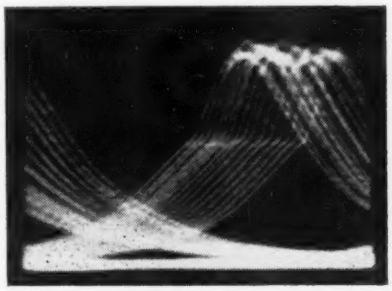


FIG. 8 SERIES OF SUCCESSIVE PRESSURE-TIME DIAGRAMS RECORDED WITHOUT SYNCHRONIZATION

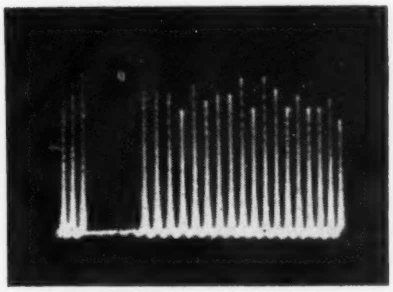


FIG. 9 SERIES OF SUCCESSIVE PRESSURE-TIME DIAGRAMS COMPRESSED TO A SHORT TIME BASE SHOWING VARIATION IN PEAK PRESSURES

To obtain the conventional pressure-volume diagram some

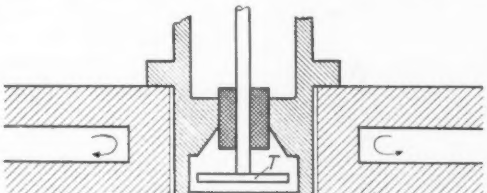


FIG. 5 MEMBRANE CONDENSER

(Capacity between electrodes *M* and *T* varies with cylinder pressure *p*.)

means must be used to give a horizontal deflection of the fluorescent spot which is proportional to the displacement of the piston. Such a device is shown in Fig. 10 and consists of a variable condenser, the capacity of which varies as the piston displacement. The cylinder is rotated on its axis by direct drive from the crankshaft of the engine and the capacity variations are converted into voltage variations, as in the case of the pressure recorder, and the voltage variations are fed to the horizontal deflection plates of the cathode-ray tube. The angle at the right-hand end of the cylinder represents the piston displacements with a connecting rod of infinite length, and the double angle on the left is a close approximation of the second harmonic which is introduced by the actual ratio of lengths of crank and connecting rod.

In permanent test installations for large engines the cathode-ray tube can be switched to the membrane condenser in each

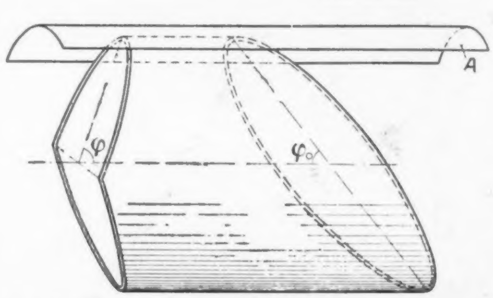


FIG. 10 ROTATING-CYLINDER CONDENSER IN THE PISTON-STROKE RECORDER

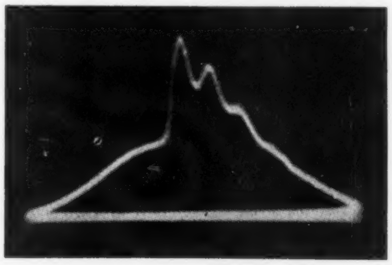


FIG. 11 PRESSURE-VOLUME DIAGRAM

(The counter electrode *A* of the cylinder condenser was here rotated 90 deg from its normal position.)

cylinder successively and the counter electrode A of the rotating-cylinder condenser rotated by servomotor to the proper position to correspond with the cylinder being indicated.

PCC Cars

ELECTRICAL ENGINEERING

IN AN article in *Electrical Engineering* for August, 1941, G. M. Woods, transportation engineer, Westinghouse Electric and Manufacturing Co., reviews the results of six years' operation of PCC (Presidents' Conference Committee) cars.

During the last six years almost 2000 PCC cars have been purchased, as well as similar types which have essentially the same electrical equipment and represent similar improvement.

On May 1, 1941, there were in operation 1467 PCC cars in 14 cities of the United States and Canada. These cars had accumulated a total mileage of more than 146,000,000, or 100,000 miles per car. The 100 cars in Brooklyn, N. Y., had an average mileage of 188,000; the first 201 cars in Pittsburgh, Pa., 206,000; and the 83 cars in Chicago, Ill., 173,500. It is evident that sufficient experience covering a wide variety of conditions is available to form a reliable basis of judgment.

The PCC car's quietness and freedom from vibration, smooth starting and stopping, superior illumination, adequate ventilation and heating, and higher speed with safety appeal primarily to the car riders, and therefore it is not surprising that revenues almost universally have increased.

The attitude of those who have had experience with the new cars is best evidenced by their new purchases. Baltimore started with 27 and now has 200 in service and on order. Cincinnati purchased 3 modern cars as an experiment and recently placed 26 more in service. Philadelphia purchased 20 originally, then an additional 130, and now has 110 more on order. Pittsburgh bought 1 experimental car, then 200 cars, then 100 additional, and has 100 more on order. Washington started with 45 and now has 232 in operation and on order. Toronto purchased 140 originally, then 50 more, and now has 60 others ordered.

Housing for Defense

(*Continued from page 666*)

Products Laboratory, the National Bureau of Standards, the Census Bureau). Direct government operations are probable in certain situations—army posts, new communities, communities where there is a shortage of capital or a shortage of facilities for private building. This survey lists in detail the various agencies available for housing construction and financing and recent legislation which bears on the problem.

One of the most serious problems which our national defense faces is housing. It is, moreover, a problem which may easily be shelved because it is not so obviously exigent as some of our other problems. The question of low-price housing has been of interest for the last few years and several programs have been inaugurated, but the pace has been accelerated and existing projects have not been adequate. The book by the Twentieth Century Fund Housing Committee is admirably designed to point out the urgency of adequate housing in relation to national defense, and the presentation of the material is excellent. The subject is difficult because the material collected here is so rapidly superannuated by the ever-changing aspects of the problem. A year in the present crisis is equivalent to a much longer period of normal peacetime development. This book is, therefore, somewhat handicapped by the very timeliness of its topic. Perhaps it will eventually be supplemented in some manner and so brought up to date. The sections on government bureaus and the legal aspects of housing are especially liable to change.

There is throughout an insistence on the separate roles of private and government operations, and several of the premises made on this subject are open to debate. More attention might well have been given to the high cost of housing construction and the steps that might be taken to prevent these costs from rising still further as a result of the defense boom. There is, perhaps also, too great a tendency to select the conditions of the last war as a basis for comparison although present requirements are admittedly rather different.

In general, the survey, as the foreword admits, "is limited by the circumstances that gave it birth." This does not invalidate its usefulness in the field of historical background, nor its logical development of the practical problems to be faced.

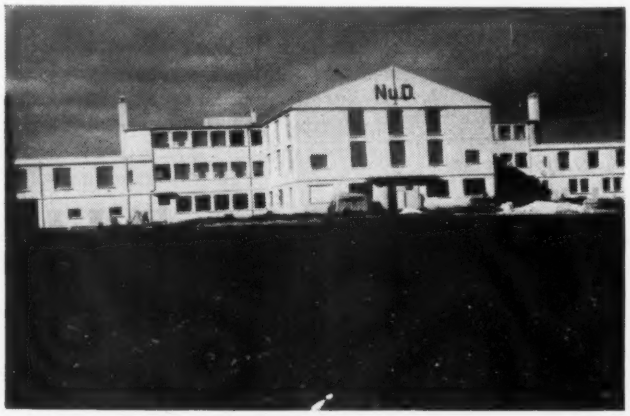
The Linde Air Products Company

MAIN ENGINES OF DAMAGED AXIS CARGO VESSELS ARE REPAIRED WITHOUT REMOVAL FROM THE SHIPS

(This view taken on an Italian freighter shows how bronze welding has made possible the repair of the main engine without the necessity for removing it from the ship. U-shaped sections had been broken out of the walls of the intermediate pressure cylinder just below the steam ports. After new sections were cast to fit the contour of the breaks, they were bronze-welded in place. Starting at the bottom of the U, the operator alternated from one side to the other every 3 in., first half-filling the vee, peening the deposited metal, then completing the weld and peening. This procedure minimized contraction stresses on cooling. The illustration shows a completed weld after the rough-boring operation.)

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects



Airplanes in Turkey

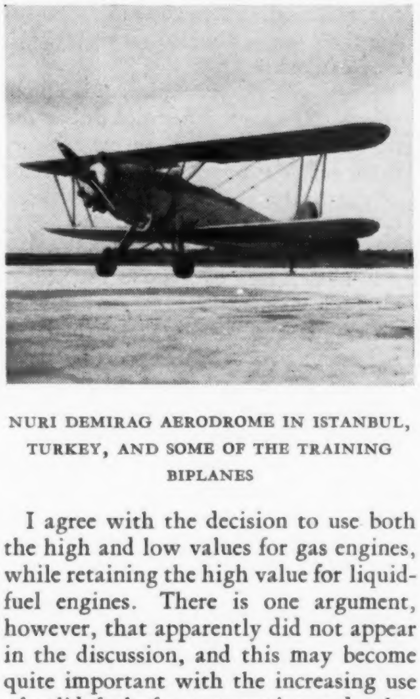
TO THE EDITOR:

Having obtained the permission of the management I am forwarding for your interest some photographs (see accompanying illustrations) of the planes built at Nuri Demirag Aircraft Works in Istanbul, Turkey, which if you think fit may be published in MECHANICAL ENGINEERING.

At the start several gliders had been built. Then the manufacture of two-seat training biplanes started. These have a steel-tube frame and wooden wings, all fabric-covered. Each one has a 150-hp Walter Gemmar radial motor and the maximum speed is 182 kmph when the loaded weight of the plane is 1000 kg.

A passenger monoplane was also built accommodating two pilots and four passengers. This is an all-metal cabin plane and has two 160-hp radial Bramo Sh 14 A4 motors. The maximum speed is 270 kmph with the plane fully loaded and weighing 1850 kg.

A. RAIF TANEY.[1]



NURI DEMIRAG AERODROME IN ISTANBUL, TURKEY, AND SOME OF THE TRAINING BIPLANES

High or Low Heating Value?

TO THE EDITOR:

I note in MECHANICAL ENGINEERING, June, 1941 (p. 493), a reference to a discussion in the Power Test Codes Committee on the use of high and low heating values, respectively, for fuels employed in internal-combustion engines.

I agree with the decision to use both the high and low values for gas engines, while retaining the high value for liquid-fuel engines. There is one argument, however, that apparently did not appear in the discussion, and this may become quite important with the increasing use of solid fuels for automotive and other purposes.

When a gas producer or a suction gas plant is used in combination with a gas engine for the production of power, it seems obvious that the high value should be used in calculating the efficiency of the producer, as this represents the amount of heat that is available in the gas. If, then, the low value is used for calculating the engine efficiency, there is a loss occurring between the two that is apparently attributable to neither of them. It seems evident, therefore, that there must be some consistency in this matter and that the high value must be used.

Further, I have never been able to see why, if the heat of water vapor is deducted from the heating value of the gas, the sensible heat of the gaseous products at exhaust temperature should not likewise be deducted, as both of them are unavailable for power production. Why make fish of one and flesh of the other? I believe that if the gas engine is incapable of using a wide temperature range, that is the fault of the engine and not of the gas.

These observations do not, of course, affect the decision of the Committee, but they do indicate that where an engine and gas producer form part of the same plant, the same basis should be employed for calculating their efficiencies.

E. A. ALLCUT.[2]

The Sixty-Year Index to A.S.M.E. Technical Papers

TO THE EDITOR:

With the help of my recently acquired Sixty-Year Index I discovered that the earliest article on military aeronautics to be published in a journal of The American Society of Mechanical Engineers was that entitled "The Present Status of Military Aeronautics," by Dr. George O. Squier. It appeared on page 639 and following of the 1908 Transactions.

In the light of actual developments I

[1] Istanbul, Turkey. Jun. A.S.M.E.

[2] Professor of Mechanical Engineering, University of Toronto, Toronto, Ontario, Canada. Mem. A.S.M.E.

can't imagine a more prophetic discussion of the subject. It would seem to me that a review and analysis of Dr. Squier's article might prove interesting and valuable to present-day readers, both laymen and those versed in aeronautics.

ARTHUR H. SENNER.[3]

Mercury-Vapor Generators

COMMENT BY A. P. KELLOGG[4]

This paper[5] on the mercury-vapor process again brings to our attention the debt which the power-generating industry owes to the author, not only for his earlier developments, but for his continued activity in the development of more efficient means for converting fuel to mechanical power.

At the present time the writer's company is prepared to furnish mercury-vapor-process equipment as required by the industry. The details of boiler design can be adapted to the particular requirements of each installation.

One point should be emphasized; the mercury-vapor portion of a power-generating station is essentially a superposed unit just as 1200-psi steam may be superposed over a 400-lb-pressure plant. The power generated per unit of fuel burned is almost independent of the pressure at which the steam is generated, however, the kilowatts generated by the mercury vapor and steam, respectively, vary with different crossover pressures.

For instance, at normal feedwater temperatures, for each 100,000 lb of steam produced, the mercury vapor will generate about 4150 kw if the steam pressure is 1200 lb, and 7300 kw if the steam pressure is 400 lb. In each case, the same mercury boiler, piping, and auxiliaries would be required, while the first case would require a slightly more expensive condenser boiler and considerably smaller mercury turbine generator.

In other words, the equipment required per mercury kilowatt is about 40 per cent more for 1200-lb than for 400-lb steam pressure. It follows that the capital investment for superposing mercury over existing steam stations will vary with each installation, but the total cost and economy of the complete generating station should be at least as constant as it is for modern steam stations.

[3] Baltimore, Md. Mem. A.S.M.E.

[4] Turbine Division, General Electric Company, Schenectady, N. Y. Mem. A.S.M.E.

[5] "Mercury Vapor for Central-Station Power," by W. L. R. Emmet, MECHANICAL ENGINEERING, May, 1941, pp. 351–356.

Industrial Lubrication

COMMENT BY MACLEAN HOUSTON[6]

The authors of this paper[7] should certainly be complimented for covering the important phases of factory lubrication in so excellent a manner. If more of our factories gave the same careful thought to the matter and installed such controls as those used by the Eastman Kodak Company, the general problem of factory lubrication would be greatly simplified. Lubricating controls for promoting preventive maintenance are one of the big problems faced by industrial plants today.

The writer would like to comment further on the oxidation of lubricating oils, a matter which is touched upon repeatedly in the paper.

The authors point out the increase in oxidation rate as the temperature of a lubricant is raised. Recent experiments have shown that at fairly high temperatures, the amount of oxygen absorbed by the same oil, other conditions remaining the same, is doubled for each 10 C increase in temperature.

Scientists today know less of the fundamental chemistry of petroleum than they do of the raw materials in nearly every other major industry. Of the thousands of compounds of hydrogen and carbon which are known to be in lubricating oil, very few have been separated and studied. Add to this lack of knowledge the complicated chemistry of nonpetroleum additives, and it will be understood why the refining industry is operating in certain cases on a cut-and-try basis and why certain lubricating problems must be solved by experimentation in the field.

We do know, however, that the oxidation of a lubricating oil may result in several different changes, depending upon the oil and the condition of the oxidation:

1 An insoluble or soluble sludge may be formed. Normally, the soluble sludge stays in solution and does not cause trouble; but the insoluble sludge which drops out of solution may cause considerable trouble by blocking oil passages or circulating pumps.

2 A lacquer or varnish-like material may or may not be formed. This, in some cases, can cause serious trouble, but in more cases only frightens the operators.

3 The viscosity of the lubricating oil may be raised to a point where it is heavier than the optimum grade for the service. Under extreme conditions, the viscosity may even be raised to a point where it will not even flow readily.

4 Probably the most important item in industrial lubrication is the type of acid which oxidation forms. A neutralization number does not truly indicate the condition of an oil, because it only indicates the amount of alkali needed to neutralize the acids still present, and these acids may or may not be corrosive. A noncorrosive acid does little harm except in assisting the formation of a water-oil-soap type of sludge if moisture is present. It may even be an advantage in assisting the oil to wet the surfaces. A corrosive acid, however, will damage bearings, gear teeth, and other polished surfaces.

The authors point this out in their Table 2. The non-solvent-refined oil after the Underwood test showed a neutralization number of 5.61; the solvent-refined oil showed a neutralization number of 2.23; but even though the neutralization number was materially higher in the case of the non-solvent-refined oil, the bearing loss was only 0.2 per cent that found with the solvent-refined oil. Numerous instances of this nature can be shown in practical operation.

As a rule, volatile acids are the corrosive acids and are formed from the lower-molecular-weight paraffins in an oil, regardless of the crude from which it is manufactured.

Certain of the heavier aromatics and probably the naphthenes act as natural inhibitors against oxidation in the conventionally refined oil, by absorbing the oxygen before the paraffins and forming soluble sludges.

In present-day practice, as oil is more highly refined, we remove its aromatics and naphthenes, leaving purer paraffins. Also, owing to the economic condition of the petroleum industry, there is a tendency to leave more low-boiling-point material in lubricating oils which are to be highly refined, partially to compensate for the loss of the undesirable elements extracted. Therefore, we have added low-molecular-weight paraffins to form more volatile acids and have removed the natural inhibitors.

To this oil then must be added an artificial or nonpetroleum inhibitor which will absorb the oxygen before certain light paraffins can absorb it and form corrosive acids. The success, therefore, of the highly refined oil is dependent upon the additive which is used, to a very great extent. These additives have, of course, been developed for what we call heavy-duty work, such as overloaded gasoline and Diesel truck and bus engines, which run at high temperatures.

[6] United Refining Company, Warren, Pa.

[7] "A Program for Industrial Lubrication," by V. M. Palmer and C. L. Pope, MECHANICAL ENGINEERING, December, 1940, pp. 861–896.

On the other hand, as the authors have pointed out, considerable trouble has been encountered in industrial lubrication in extremely low-temperature work; but, as we have seen, the majority of the corrosive acids are the more volatile acids which are not distilled off in low-temperature industrial work, as they are in high-temperature internal-combustion engines, and remain to do their damage.

Therefore, the increase in neutralization number can only be used as a guide to the life of an oil when experience has shown the point where damage occurs in the particular equipment, using a particular oil. It cannot be used to compare oils refined to different degrees or from different crudes. Usually, even an oil that has caused serious corrosion during service is noncorrosive when removed from the machine, because the volatile acids have been dissipated by evaporation or have been changed to metal soaps or salts.

The question which the reader will have in mind is reasonable: Why do we go to excessive refining when we produce certain hazards? Excessive refining can and does to a large degree stop the formation of insoluble sludge, stop the formation of lacquer, and reduce the viscosity increase to a reasonable figure, the results of which are a clean-looking engine after hard service. Therefore, it clears up three of the big problems and handicaps us only on the fourth. A corrosion inhibitor can be found for a certain oil in a certain job, but can we expect to carry sufficient types of oils to cover all of the jobs at hand? The refiner is up against the same problems as the industrial plant, i.e., his costs are dependent upon the number of oils he manufactures and stocks.

The foregoing thoughts can, in our opinion, be carried further to question the statements made by the authors that an oil with a good demulsibility is more apt to leave rust than one without such a good demulsibility. Years ago, demulsibility was the chief criterion of the value of a turbine oil, but the present extreme refining methods were not known, and rust in a turbine or gearbox was practically unheard of. Some of these oils had just as good or better demulsibility when new than the present highly refined oil.

For these reasons, some of us are studying the formation of rust and corrosion found in certain equipment, as pointed out by the authors, from the standpoint of the corrosiveness of the acids formed by the particular oil in the particular service, rather than from the standpoint of demulsibility or amount of refining to which the oil has been subjected.

COMMENT BY B. F. HUNTER[8]

Automatic application of a lubricant is of equal importance to the selection of the correct lubricant to insure maximum performance and machine life. A broader knowledge among designers of the importance of the proper application of a minimum number or kinds of lubricants to a given unit would simplify the problems of the plant operator and insure the maximum life and performance of the unit.

Far too frequently, we encounter small mechanical units, designed for and specifying as many as six different lubricants for no more than ten to fifteen bearings or parts requiring lubrication. The average industrial plant, employing numerous similar machines of various manufacture, involving variable methods of applying lubricants, presents a lubricating problem which no plant operator can follow practically.

A careful study of the lubricating requirements of a specific plant and standardization of lubricants and methods of application will pay dividends to any industrial plant.

COMMENT BY O. L. MAAG[9]

The authors have given a good outline of how they have successfully solved lubrication problems in their plants, which will serve many lubricating engineers well as a guide to take care of problems that confront them. However, it may be well to stress the point that each plant is in general a different unit and as such will require many deviations from any set guide. It is evident that the authors recognize this fact. It must also be borne in mind that, in order to operate a plant economically, the number of lubricants must be kept at a minimum, so as to avoid mixups, hence compromises must be made here and there. We have found that it is desirable to give the purchasing departments several sources of supply for each product so that the buying may be done efficiently and economically.

We believe in specifications for oils and greases, however, they should not attempt to be too complete. They should be so written as to give the supplier the necessary information, in order that he can choose the proper lubricant from among his many regular products without penalizing his company because of lack of certain type stocks. Compounding, refinement, stability, type of oil, etc., must be handled by the manufacturer and it should be his duty to see that what he sells is entirely adequate from all angles to lubricate the unit satisfactorily.

Machinery that is properly designed, engineered, and built is usually not difficult to lubricate properly. The free exchange of ideas between the designing engineers and the lubrication engineers, while the machine is still on the drafting board, will usually produce a piece of equipment that operates trouble-free. We must, however, be fair to these men in that many times they are not to blame, as space allowed for bearings and lubricant layout is not sufficient for the proper-size bearing to be used for the loads and speeds encountered, nor can the best layouts be made for correct lubrication. Usually, these machines are problems for both the lubrication engineers and the users. We have had machines that gave trouble with oil oxidizing and sludging, which ran trouble-free merely by enlarging the oil reservoir in the circulating system.

We prefer oil lubrication wherever possible; however, operating conditions are such that most antifriction bearings today are being lubricated with grease.

We strongly recommend constant-level oiling units as they insure the proper amount of oil in the bearing housings at all times, eliminating the troubles mentioned by the authors of overlubrication. Self-contained oiling units, where oil is supplied by splash feed or pump, are usually the nearest to being foolproof and pay big dividends to the builders and users of such machines. However, a stable oil must be used in these units. Furthermore, a large enough reservoir must be provided so that the temperature of the oil does not go so high as to cause too rapid oxidation and thickening, as even the best and most stable oils will break down under continued high temperature. On such units as these, periodically, when changing the oil in the sump, we add about 10 per cent of carbon tetrachloride and operate the machine lightly for a few minutes so that all the gums and oxidation products are dissolved and put into solution in the oil. This mixture is then drained out completely and the unit filled with new oil. The properties of used oils which change most rapidly are the color, acid number, and viscosity, as the data given by the authors indicate. Periodic checking of these properties will serve as a guide as to when the lubricant should be changed. Our experience indicates that the oil companies have oils today that are quite stable up to temperatures of about 175 F. For higher operating temperatures, frequent changes of lubricant are needed, if it is expected to operate free from gumming, sludging, etc.

[8] Gulf Oil Corporation, Pittsburgh, Pa.
[9] Lubrication Engineer, The Timken Roller Bearing Company, Canton, Ohio.

On circulating systems which are inclined to run hot and dirty, we have materially improved the life of the oil as well as operating conditions by filtering and by cooling the oil with water coolers.

In hydraulic systems, our experience agrees with that of the authors in that the lighter-bodied oils run cooler and, therefore, with less oxidation and sludging. Our experience further agrees with that of the authors in that, on the same machine, a higher-viscosity oil will run hotter, to the extent that, at the operating temperatures, each oil has the same body or viscosity.

Stability of greases, as regards oxidation, gumming, etc., and thinning out in service cause most of the lubricant complaints where grease is used. Improper and faulty or damaged closures lead to complaints from the leakage of thinned-out grease. These are aggravated, as the authors note, by too much grease in the antifriction-bearing housings. We recommend that the housings be no more than $^1/_3$ to $^2/_3$ full of grease, which allows space for expansion. To control the amount, in certain housings, we have installed overflow outlets at the desired level, so that in operation the excess grease escapes. The addition of inhibitors to oils and greases is in certain cases desirable.

The lubricant manufacturer should be encouraged to make the most stable product he can within economic limits; however, the builder of a machine must not demand too much.

The authors show illustrations of parts of antifriction bearings which have pits from water corrosion, also parts badly spalled. Water with its corrosive action probably gives the antifriction-bearing manufacturers more trouble than any other cause. The corroded areas weaken the surfaces and are often the forerunner of the spalled and fatigued areas exhibited. The designing engineer should, therefore, do all he can to prevent water from entering bearing housings. If the indications are that only a small amount of water will enter the bearings, we take care of it with a soda-soap grease, but when there is a tendency for considerable water to enter the housings, as in steel mills, we use lime-soap products and fill the housings, periodically forcing in new grease which forces the thinned watery lubricant out an overflow or by the bearing closures.

In conclusion, we feel that, to obtain the best results, continual cooperation among machinery builders, users of the machinery, and the lubricant makers will keep our difficult lubrication problems at a minimum.

COMMENT BY H. T. MORTON[10]

This paper shows a careful study of plant lubrication and the difficulties which are encountered in improper lubrication, as well as failures which occur normally and abnormally. We are particularly interested in the remarks relative to lubrication of ball bearings.

We wish to emphasize that excessive grease or lubricant in a bearing will cause overheating and resultant bearing failure. The statement that good practice for grease-lubricated antifriction bearings calls for bearing housings to be about one third full of grease is in agreement with our experience. The authors' suggestion of leaving the drain plug open when greasing a bearing is one way of trying to prevent overlubrication. It is a matter which should be impressed upon all workmen who lubricate ball bearings. This same condition should be engineered into the design of all new equipment using ball bearings, to be sure that there is an opportunity for relubrication with overflow to prevent overlubrication.

It has been our standard practice to sound-test all ball bearings before shipment, thereby detecting any manufacturing defect, dirt, or other items which might cause early failure or trouble. Sound-testing ball bearings in service quickly detects those bearings which are about to fail, before the incipient failure becomes so grave as to stall the machine or cause other damage. The operator must gain experience with this method before he can definitely decide which bearings should be removed and replaced or which ones can be continued in use.

The authors' suggestion of using a thinner oil on bearings which are operating at high temperatures is typical of what can be accomplished. The statement to the effect that the lighter oil decreased the bearing temperature, so that the bearings operated with the oil at the same viscosity at the lower temperature as they did at the higher, should be considered carefully by lubrication engineers. In other words, this heat was generated by the internal friction of the oil rather than by friction of the ball bearing itself.

The writer's company and other bearing manufacturers have studied the matter of oxidation of greases in detail during the last few years. It is becoming more and more a standard practice for oils and greases now in use for lubrication on ball bearings and roller bearings to contain an oxidation inhibitor, thereby preventing the breakdown of the lubricant with resultant formation of acids which corrode the ball and bearing surfaces.

[10] Chief Metallurgist, Hoover Ball and Bearing Company, Ann Arbor, Mich.

COMMENT BY A. B. WILLI[11]

The statement, "Attention to the lubrication requirements during the design period results in fewer lubrication and mechanical difficulties after the machine is placed in service," no doubt includes the method of lubricant distribution within a sleeve bearing. The grooving in a sleeve-type bearing is one of the very vital points which affects lubrication.

The writer finds a growing tendency to discount the value of all oil grooves. Some of this is perhaps due to unfortunate experiences with improperly designed grooving systems, and some may be due to the individual's interpretation of the familiar diagram of "longitudinal pressure distribution in a bearing oil film."

Correct grooving, with the directed distribution of lubricant within the bearing thereby obtained, will usually insure the success of any sleeve bearing, providing the other elements involved are also correct. Improper grooving will guarantee an unsuccessful bearing, regardless of how much of the design is otherwise correct.

The reference to the selection of lubricants to match construction material coming in contact with the lubricant is particularly important, when sleeve bearings lined with copper-lead mixtures or cadmium alloys are used. Lubricants containing oleic acids or animal fats added to increase oiliness characteristics are likely to be very harmful in promoting corrosion.

Harmful and corrosive acids, which attack these types of bearings, are sometimes formed even in pure mineral oils, under certain conditions of high-temperature operation.

The so-called copper-lead bearings are made with a lead content within a range of 30 to 40 per cent, the remainder being mainly copper. The metals do not combine, and small particles of lead are frozen into the mass of copper. It is these lead particles which are attacked by the acids and a lead soap is formed, which is more or less readily washed away, leaving a porous copper structure.

In the cadmium-alloy bearing, the entire surface is attacked, leaving an etched and blackened surface.

Bearings of these types are extremely useful where shaft speeds are high, and the loads are in excess of the capacity of conventional white-metal bearings, but they are sensitive in regard to their lubricant.

AUTHORS' CLOSURE

Mr. Houston's comment on the mecha-

[11] Chief Engineer, Federal Mogul Corporation, Detroit, Mich. Mem. A.S.M.E.

nism of the breakdown of petroleum oils in service is a real contribution to the practical engineer.

Time alone will tell whether the older oils which caused insoluble sludges to form and deposit in lubricating systems cause more trouble than the newer oils which form soluble oxidation products, and give a clean system generally at the expense of rusting, corrosive acids, and lack of oiliness. We will grant that in some Diesels, some topping turbines, and some automotive equipment the newer types of oil may be justified. Generally speaking, from our experience insoluble sludges thrown out of the oil caused very little trouble.

Normally most industrial equipment, where continuity of production is essential, has a preventive maintenance program calling for machine inspection long before the sludges cause trouble. At this inspection period it is a relatively simple matter to remove the sludge.

Mr. Houston questions the statement that high-demulsibility oils permit rapid rusting in the presence of water and further writes that some older oils with high demulsibility did not permit rusting. A possible explanation of this may be that the older types of oils underwent a rather rapid initial oxidation, the oxidation products formed increased the wetting ability of the oil and lowered the demulsibility. Thus there was only a short induction period wherein rusting would be anticipated. The newer oils, which resist oxidation because of inhibitors, have a long induction period in which rusting can take place. This therefore greatly increases the chances of some water getting into the system with consequent rusting. During this next year we propose to measure these induction periods with the idea that it may be better to preoxidize an oil and shorten the useful life but prevent rusting and corrosion. In the meantime it is hoped that Mr. Houston's study of the corrosive acids formed may guide the refiner so that rusting and corrosion need not be expected from a new oil.

Mr. Hunter seconds our plea that machine designers become more lubrication-conscious so that they may provide more generous bearing areas and lower unit pressures thus avoiding special, and often trick, lubricants and need for complicated lubrication practice.

The machine purchaser and user should check to insure that the equipment purchased has the foregoing considerations built into it. For example, automatic spray ovens with the bearings inside cause considerable trouble from the oil carbonizing. Degreasers with the bearings unprotected from the solvent wash and splash come in the same category. Just a little reasoning by the designers in these instances would make all the difference between a highly successful machine and one that all its life is a source of trouble and expense.

For removing oil deposits Mr. Maag's recommendation of carbon tetrachloride has been unsatisfactory in our experience. After cleaning with it, often slight traces remain which hydrolize to form hydrochloric acid. This has caused corrosion. Because of this, use of carbon tetrachloride is prohibited and a petroleum fraction with a minimum flash point of 125 F is specified.

With some oils we have found that the contained-oxidation inhibitor is not enough to insure freedom from corrosion and it is necessary to add an additive for this. This is probably due to the light acid fractions mentioned in Mr. Houston's discussion. We have ball bearings running without corrosion or rusting as an experiment in which the oil now has a neutralization number of 5.76. The same oil permitted rusting when the neutralization number was below 0.14. Very little trouble has been encountered with greases.

Bearing grooving mentioned by Mr. Willi merits more space and a paper or treatise on this subject would be of value to the engineer. Too many articles on this subject are limited and apply to a specific bearing.

The authors are greatly indebted to the discussers for the thought and care with which they prepared their remarks.

V. M. PALMER.[12]
C. L. POPE.[13]

[12] Superintendent, Industrial Engineering Department, Eastman Kodak Co., Rochester, N. Y. Mem. A.S.M.E.

[13] Lubrication Engineer, Eastman Kodak Co., Rochester, N. Y.

The Annis Meter

COMMENT BY R. J. S. PIGOTT[14]

The writer was greatly interested in the paper,[15] describing the Annis intake meter, inasmuch as in 1909 or 1910 he made up a similar meter on the suction of a centrifugal circulating pump at the Interborough 59th Street Power Station in New York City. No special fittings were substituted for the regular intake, which was of the bellmouth type, and a single tap was employed as the intake conditions were quite satisfactory to avoid swirls. The nearest approach to this shape is Fig. 5, in the paper, which instead of using a straight cone, as ordinarily employed in the venturi, approximates the bellmouth.

The two advantages of the bellmouth are that, having the full flare, it receives the liquid from the floor of the intake chamber in a natural manner and is a standard type of construction used during the last 30 or 40 years for good pump connections. In addition, it avoids any possibility of a vena contracta at the mouth of the straight cone, as shown in Fig. 4 of the paper. As used in ordinary venturi meters, the straight cone does not produce any vena contracta because the flow is axial but, in a pump suction, the general flow is apt to be more nearly radial, and the chance of vena contracta at the entry of the straight-cone mouth is quite pronounced. The general tendency, of course, is to reduce the coefficient of the device.

With regard to the use of a piezometer ring, it is now quite clearly established that, if the entry conditions are free from swirl, a single throat tap is as accurate as a piezometer ring. If the intake conditions are such that there is pronounced swirl, neither device will give the right answer. For pipes 12 in. and larger, the rough-cast throat without an inserted finished bushing will be found quite satisfactory, as the speeds involved in the suctions of centrifugal pumps are not high and, in this size pump and larger, the roughness effect is practically nonexistent.

In the interests of a more widespread use of such meters for measurements of flows in all kinds of centrifugal pumps, it is of course desirable to cut the cost of any special fittings involved. The use of the regular bellmouth cast pipe with a single tap would cut the cost of the entrance piece quite appreciably.

The use of guide vanes is generally desirable to eliminate any possibility of swirl, in case the intake well is not satisfactory in itself. In the case of the bellmouth pipe, four or more vanes may be applied vertically under the turn of the bellmouth so as to act either as feet for the pipe, if it must be supported from the bottom, or as guide vanes for the radial flow. They will be found very effective in this position. If these are used, there is no necessity to add vanes in the interior of the pipe which would require more core work in casting.

[14] Staff Engineer, Gulf Research & Development Company, Pittsburgh, Pa. Fellow A.S.M.E. and Past Vice-President.

[15] "The Annis Meter," by M. B. MacNeille and R. K. Annis, MECHANICAL ENGINEERING, April, 1941, pp. 281–285.

There is little doubt that the Annis meter can be used as a satisfactory and accurate method of measuring water and, in many cases, it will be convenient and much less expensive than the ordinary venturi-meter installation. For many purposes, such as circulating water for condensers, an accuracy of better than 1 per cent is not necessary in any case, and the rough-cast bellmouth intake piece with a single tap is all that is justified. For cases where the water is to be measured accurately and, particularly, for all cases of pipes smaller than 12 in., a machined throat with a carefully finished tap is probably essential, just as it is in the small venturi meters.

The writer believes that this type of meter will find many applications in pumping water. The authors are to be congratulated on having presented not only a useful method of measurement but one which may be made relatively inexpensive.

COMMENT BY C. G. RICHARDSON[16]

The shape and restricted length of the suction and discharge pipes often used with screw- and propeller-type pumps have militated against successful metering of the flow. The original work of the authors of this paper therefore in the development of a practical solution deserves commendation. That the invention of a new type and design of meter has resulted, however, seems doubtful.

The final design arrived at is obviously a form of venturi tube. The omission of the inlet-pressure chamber, using instead the head in an inlet basin, has rather frequently been employed where the space available for the venturi tube has been limited. In such installations, the water enters the tube through a well-rounded approach, the inlet velocity head becomes entirely negligible, and the venturi formula reduces to the simple equation for V, as given by the authors.

The elevation of manometer differentials, for convenient observation, to a level above the hydraulic gradient by a negative air pressure also has often been used, particularly in filtration and sewage plants where operating heads are low.

Any conical shape which produces an appreciable change in velocity of flow through it is a "venturi tube." However, only after the coefficients of such shapes have become thoroughly established by a long series of carefully conducted calibrations, preferably of a volumetric nature, for a variety of sizes and ratios, can they be considered thoroughly reliable. Incidentally, the interior finish of the throat and its approaches, the design and machining of the vent bushings, and the like, are elements, the importance of which for accurate performance is not always recognized. One is led to inquire therefore why venturi sections of standardized design should not be employed in the suction lines of propeller pumps instead of developing special shapes? As to available space, standard designs do not require as long a straight portion of throat as is shown in the sketches accompanying the paper. A standard venturi-inlet section would be somewhat shorter in over-all length than the 30 × 20-in. section shown in Fig. 5 of the paper.

The paper mentions that earlier tests were less accurate than more recent ones; apparently, the former apply to the intake sections shown in Figs. 5 and 6. Later a section, having a 6-in. throat made to the proportions of Fig. 4, was tested against flow nozzles. It is recommended that the proportions of this small-size unit be adopted for all sizes. This is difficult to approve readily, particularly when one notes the short length of the zone in which the points fall on the A.S.M.E. coefficient curve. The dimensions of Fig. 4 do not conform to standard venturi inlet and throat sections.

The design of the manometer with its attached vacuum pump is ingenious, and the "practical notes" regarding installation contribute importantly to this particular application.

[16] Manager Municipal Sales, Builders Iron Foundry, Providence, R. I. Mem. A.S.M.E.

COMMENT BY E. S. SMITH[17]

It has long been a mere matter of convenience to use either a pipe or an unrestricted entrance in obtaining the pressure upstream of a venturi throat. Such has been the state of the art ever since the conception of the venturi meter by Clemens Herschel. An appreciation of the principle is manifest in the works of Venturi. Consequently, some question may properly arise over the use of the name of any contemporary in connection with a venturi in which the pressure at the inlet is taken in a large container instead of the usual pipe.

However, the authors should be commended for presenting for discussion an interesting approximate agreement of data on two different shapes of venturis (the conventional streamlined venturi which has the inlet tap in a pipe and the Annis design which has no fairing at either the throat or the inlet). Hence, it can be made clear that the agreement does not indicate the shapes to be essentially identical but that such agreement requires there be apparently compensating effects.

Mikita[18] used a similar unfaired throat in his design of venturi, the coefficients for which fall considerably below those of the Herschel standard.[19]

Streamlining is generally economically sound for large meters extensively used for liquids. However, where there is no transition curve between inlet cone and cylindrical throat, the throat connection may be taken in the inlet cone near its intersection with the cylinder. The throat area to be used in calculations is not taken on a plane section but must be the area of the cone-enclosed section of the sphere which includes the pressure tap. The center is at the apex of the inlet cone so that the streamlines are normal to the area, which is necessary in order that the usual venturi formula may apply. This location of the throat tap may be desirable where it is not essential to have the maximum possible metering depression, i.e., in cases where loss is not important and where cavitation is not likely to occur. Concerning an unfaired intersection of the inlet cone with the throat cylinder, flow simply does not reliably follow a sudden moderate change of direction of a guiding wall.

This general principle is also violated at the entrance which had better be made bell-shaped or with a rounded edge. Otherwise the entrance forms a re-entrant nozzle which would theoretically have a contraction coefficient of $^1/_2$ with a cylindrical pipe and even less with a cone such as applied to the authors' venturi. Since the loss accompanying the stated coefficient of $^1/_2$ is $^1/_3$ of the velocity head of a stream which would fill the area,[20] a perceptible lowering of the coefficient is to be expected with even a small ratio of diameters of throat to inlet. It may be interesting to note that the authors' meter is in a true sense an equivalent of a cylindrical re-entrant nozzle having a vena-contracta connection at $^1/_2$ of the outside diameter from the inlet edge and a coefficient of approximately 0.53 where the external area of the pipe is used in the calculations.

Comparing the design of the authors' venturi with that of Herschel, the relatively bad hydraulic design of both the inlet and the throat of the former must tend to increase the metering head and correspondingly lower the coefficient.

[17] C. J. Tagliabue Manufacturing Company, Brooklyn, N. Y. Mem. A.S.M.E.

[18] "Calibration of Small Venturi Meters," by J. J. Mikita, *Instruments*, vol. 9, 1936, pp. 2, 3.

[19] "Relations Involved in Metering Rate of Flow," by E. S. Smith, *Instruments*, vol. 12, pp. 115–126; refer to Fig. 25–16, and its context.

[20] Reference (19), section 5, p. 121–122; and especially Fig. 25–15.

With the standard design installed in a pipe, the effect of the upstream pipe friction is to increase the inlet velocity head $\alpha V_1^2/2g$ by increasing α which reduces the metering head and raises the coefficient. In other words, since each departure from the conventional design appears to lower the coefficient, the reported agreement of coefficients for the two different shapes remains unexplained. According to this writer's experience, venturi coefficients are considerably more sensitive to changes of shape than the paper would imply.

COMMENT BY R. E. SPRENKLE[21]

The subject matter of this paper is especially interesting since it represents the theoretical development of a certain type of metering equipment which has already been put into practical operation.

Approximately 2 years ago, the writer's company made an installation of fifteen water-flow meters in five different pumping plants of the Metropolitan Water District of Southern California. All of these meters were connected to the inlet cones of the station pumps, all of which cones resembled generally the cone illustrated in the authors' Fig. 4. Further details of these inlet cones are shown in Fig. 1 of this discussion. From this drawing, it will be noted that two of the pumping stations used that shape of inlet cone, shown in the left-hand view, two stations used that form of cone shown in the center, and the remaining pumping station used that cone shown in the right-hand view of Fig. 1. It will be noted further that the meters supplied for the Eagle Mountain and Hayfield Reservoir Pumping Plants, as illustrated by the center view, had merely an inlet cone without struts or braces, whereas, the Intake, Gene, and Iron Mountain inlet cones possessed struts because of their relatively larger-diameter bellmouths.

These inlet cones were furnished by the Metropolitan Water District, who in turn advised us the maximum differential or loss in pressure between the points marked K1 and K2 for which to design the metering equipment. This information was obtained by actual field tests on each individual pump. It is of interest to note the average coefficient of discharge for the Intake and Gene pumping station meters, based on a maximum flow of 300 cfs, was 0.985. For the Eagle Mountain and Hayfield pumping plants, the average coefficient was 0.988. Since the Iron Mountain inlet section was considerably shorter than those for the other four stations, and because the equivalent diameter ratio, that is, the ratio of the small to the large diameter of the cone, was considerably higher than any of the others, the value of the coefficient of discharge was considerably lower, namely, about 0.84. The coefficients of the Intake, Gene, Eagle Mountain, and Hayfield Reservoir installations therefore agree very closely with the data given in Fig. 9 of the paper.

Several of the advantages listed by the authors need further clarification. The first of these is the statement that the intake meter does not require as much straight pipe on the inlet side as do nozzles, orifices, and venturi tubes. There is nothing fundamentally different between the Annis meter and the standard nozzle, orifice, or venturi tube. Thus, for similar service, straight pipe on the inlet side is not required in order to produce satisfactory metering accuracy. As proof of this we would refer to a paper[22] by N. C. Ebaugh and R. Whitfield. The scheme, used in that paper, employed an orifice at the inlet to a round duct, using only the orifice-outlet connection for measuring the differential pressure between the atmosphere and the pressure beyond the orifice. In this work, the authors found the orifice so installed to be quite reliable. Similar experiments were carried out in Germany which were covered in a paper by E. Stach.[23] In this work thin-plate orifices were also installed at the inlet to ducts.

The only purpose of the exit tube used in standard venturis is to provide a greater pressure restoration than would be obtained beyond the venturi throat if such restoring cone were omitted. In the Annis meter none of the drop of pressure between the inlet edge and the throat is restored beyond the throat. If it were desired to follow the same procedure with the use of any other type of primary device, no extra cone would be needed with a venturi or flow nozzle.

The loss of head is that occasioned by the change of energy between the inlet edge of the primary element and the throat section because of the acceleration of the flow. Beyond the throat section there is a restoration of pressure, not a loss, as inferred in "Advantage No. 3" given by the author.

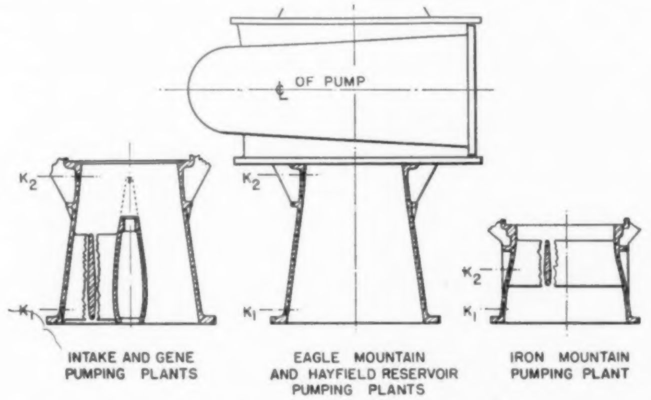


FIG. 1 ARRANGEMENT OF PUMP INLET SECTIONS, METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

AUTHORS' CLOSURE

The authors appreciate the several discussions of their paper. It is particularly gratifying to find that the experiences of the discussers corroborate in general the data given in the paper.

In his discussion, Mr. Pigott raises the question of vena contracta. The laboratory tests on these meters did not include a recording of the flow pattern, nevertheless the designs were subjected to theoretical studies of the flow before construction. The accuracy of these studies was substantiated later by the calibration tests. For example, with the meter shown in Fig. 5 of the paper the side walls are shaped approximately the same as a vena contracta, and therefore there is no separation of the flow from the walls. With the meter shown in Fig. 4 there is a curved entrance to the cone at the large diameter. This radius is large enough to prevent the formation of vena contracta. That this is so is evidenced by the satisfactory coefficients obtained when this shape was used.

Even the fabricated meters as shown in Fig. 6 gave a fairly high coefficient, showing that any vena contracta, if present, did not interfere with the accuracy.

[21] Bailey Meter Company, Cleveland, Ohio. Mem. A.S.M.E.

[22] "The Intake Orifice and a Proposed Method for Testing Exhaust Fans," by N. C. Ebaugh and R. Whitfield, Trans. A.S.M.E., vol. 56, 1934, pp. 903–911.

[23] "Die Beiwerte von Normdüsen und Normblenden im Einlauf und Auslauf," by E. Stach, *Zeit. V.D.I.*, vol. 78, 1934, pp. 187–189.

The authors agree with Mr. Pigott that a bellmouth would be entirely satisfactory, although they know of no calibration data in this connection.

Mr. Pigott also comments on the use of guide vanes. These were tried in one of the meters, as shown in Fig. 6 of the paper, but were eliminated on later designs without any loss in the accuracy.

Mr. Richardson inquires why venturi sections of standardized design should not be employed in the suction lines of propeller pumps instead of developing special shapes. The answer to this is rather thoroughly explained by Mr. Pigott in his discussion, pointing out that the flow approaching a conventional venturi is axial, while on the other hand with the Annis meter the flow just in front of the cone is more nearly radial. For this purpose, the authors believe the slight bellmouth, shown in both Figs. 5 and 6, to be useful in cutting down the resistance to flow, and also in preventing fluctuations. The authors agree with Mr. Richardson that a standard venturi section would be satisfactory, provided however that some form of rounded approach is added. This would have the added advantage of using equipment which is already available in commercial form.

The authors agree with the comment that the fundamental principle of this meter is similar to the laws governing flow nozzles and venturi meters, but it has required extensive alteration of these well-known forms of meters to accomplish the particular purposes to which the new meter has been applied. With equal care in manufacturing and calibrating, this new meter has accuracy equal to the venturi, or to any of the better known meters already available, with the added advantages of smaller space requirements and lower cost.

Mr. Smith's suggestion of connecting the throat tap into the cone section instead of the small cylindrical section is interesting. Calibration tests, however, would be necessary to prove whether there is any practical advantage in doing this.

The authors agree with Mr. Smith that venturi coefficients are sensitive to change in shape. In fact data are presented in the paper demonstrating this. With any of the shapes tested in this program, however, the effect was not great; and any error from this cause will be entirely avoided by constructing meters strictly in accordance with the generalized dimensions given in Fig. 4 of the paper.

Mr. Sprenkle's experiences on the Metropolitan District of Southern California are interesting. One of the authors (Mr. MacNeille) visited the five installations of the District. The use of vanes in the meters under discussion is interesting, particularly at Iron Mountain where the K2 tap is taken off in the region of the vanes. It is thought possible that these vanes may have had some influence on the coefficient at that station.

Mr. Sprenkle asks for a clarification of the claim that there is no loss of head in this meter. This statement is based on the recommendation, made in the paper, that the throat of the meter be of the same diameter as the suction pipe. If this is done, the total length of the suction pipe, including the meter, is only as long as the pipe would be without a meter. Further, there is no reduction of diameter, as required by a venturi meter, and hence no recovery tube. As a result, the meter adds no friction whatever to the friction of an equivalent length of suction pipe. With a venturi meter, on the other hand, there is a well recognized loss of head which according to research work done on fluid meters[24] is 10 to 20 per cent of the venturi head.

M. B. MACNEILLE.[25]
RUSSELL K. ANNIS.[26]

[24] "Fluid Meters; Part 1—Their Theory and Application," Fourth edition published by The American Society of Mechanical Engineers, New York, N. Y., 1937.

[25] Chief Engineer, Hydraulic and Dealer Division, Fairbanks, Morse & Company, Beloit, Wis. Mem. A.S.M.E.

[26] Consulting Hydraulic Engineer, Asheville, N. C. Mem. A.S.M.E.

Books Received in Library

ÄTZHEFT, Anweisung zur Herstellung von Metallschliffen Verzeichnis von Ätzmitteln Verfahren zur Gefügeentwicklung. By A. Schrader. Third edition, revised. Borntraeger Bros., Berlin, Germany, 1941. Cloth, 6 × 9 in., 28 pp., charts, tables, 1.60 rm. Etching processes and the solutions used in preparing metallic surfaces for metallographic inspection are presented in concise tabular form, with special attention to the differentiation of intermediate crystal types of aluminum alloys. Both the text and bibliography have been revised in this new edition.

AIR AND GAS COMPRESSION. By T. T. Gill. John Wiley & Sons, Inc., New York, N. Y., 1941. Cloth, 6 × 9 in., 181 pp., illus., diagrams, charts, tables, $3. This new textbook discusses the properties of gas in regard to compressibility, critical data, and specific heats, as applied to the solution of the problem of air and gas compression. Illustrative problems with solutions accompany each chapter, and practical alignment charts are appended.

AIR RAID PRECAUTIONS, in ten parts, reprinted by permission of the Controller of H.M.S. Stationery Office, first American edition, Chemical Publishing Co., Brooklyn, N. Y., 1941. Cloth, 5½ × 9 in., diagrams, charts, tables, $3. In the ten separately paged sections of this manual are brought together and amplified the materials published previously in the A.R.P. handbook and memorandum series. Topics discussed include the organization of the air-raid wardens' service, communications systems, rescue parties, and clearance and decontamination work; structural defense and window protection; gas detection and identification; training procedures and inspection, care, and repair of equipment.

AIRCRAFT INSTRUMENTS, Their Theory, Function, and Use. By O. E. Patton. D. Van Nostrand Co., Inc., New York, N. Y., 1941. Cloth, 6 × 9½ in., 220 pp., illus., diagrams, charts, tables, $2.75. Intended both as a textbook for the student and a practical manual for the aviator or mechanic, this book presents a clear, concise discussion of the various flight, navigation, and engine instruments. Design and construction are described in such a way that the nature, principle, functioning, and purpose of any instrument can be readily understood. Many photographs and diagrams supplement the text.

AIRCRAFT PROPELLERS, Basic Training Manual. By C. M. Harlacher, prepared and edited by H. E. Baughman. Aero Publishers, Glendale, Calif., 1941. Cloth, 6 × 9½ in., 119 pp., illus., diagrams, charts, tables, $2.85. Intended as a basic training manual, this book presents in question-and-answer form the fundamentals of propeller theory, construction, and maintenance. The Civil Aeronautics Administration regulations are covered.

CORRECTING OIL-BURNER DEFICIENCIES, With Special Application to Pressure-Atomizing Oil Burners. By Z. Kogan. Zuce Kogan Consulting Service, Chicago, Ill., 1941. Cloth, 6½ × 9½ in., 152 pp., illus., diagrams, charts, tables, $5. The variation in efficiency between test runs and general operation in oil-burning power plants is considered by the author, a consulting engineer, to be due to dependence on certain traditional concepts which no longer apply. Under the following headings: Mixing of oil and air, furnace heating zone, fineness of atomization, and burner applications, he presents new concepts and techniques for correcting oil-burner deficiencies particularly in pressure burners.

GENERATOREN. (Handbuch der Gasindustrie, Bd. 2.) Edited by H. Brückner. R. Oldenbourg, Munich and Berlin, Germany, 1940. Cloth, 6½ × 9½ in., 304 pp., illus., diagrams, charts, tables, 23 rm. The various types of gas producers are described in detail, with many illustrative drawings, graphs, and diagrams. The installations covered include large permanent plants and small portable ones for powering vehicles, continuous and discontinuous operation, and the production of gases for a great variety of purposes and from many materials.

A GOOD MECHANIC SELDOM GETS HURT. By H. R. Graman. American Technical Society, Chicago, Ill., 1941. Paper, 5 × 7 in., 94 pp., illus., $0.50. The object of this collection of safety rules is to give the beginning craftsman an idea of what to look out for when working in a machine shop. For simplicity the safety precautions for each machine have been grouped together. Review questions on safety in the machine shop appears at the end.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

Industries of Louisville Cooperate to Make A.S.M.E. Fall Meeting of Compelling Interest

Rich and Varied Program of Technical Sessions and Social Activity Is Planned for the Days of October 12 to 15

LOUISVILLE'S industries are cooperating to the maximum to make the A.S.M.E. Fall Meeting, October 12 to 15, one of the best ever held in the history of the Society. Variety in the subjects for the technical sessions will challenge the interest of those in every branch of industry, with plant trips serving as excellent illustrations for several of the technical papers.

Registration to Start on Sunday

Registration will start at 2 p.m., Sunday, October 12, at the headquarters for the Meeting, the Brown Hotel.

Not to be outdone by the technically-minded, the entertainment committee is out to prove that good times can be sandwiched in with interesting sessions—to the benefit of both. Of special interest to those at the Meeting will be the Horse Show and Barbecue Dinner which are being planned. At the Show some of Kentucky's prize thoroughbreds will compete for honors. The setting will be in a beautiful park on the outskirts of Louisville.

War Department Display of Ordnance Matériel

The War Department has consented to have on hand a traveling display of ordnance matériel—all samples of products in the process of manufacture in the Louisville and Cincinnati districts.

Another exhibit of special interest will be that staged by the Wood Industries Division of the Society, showing products and recent developments in that field.

Don't Miss Mammoth Cave Trip

A special invitation is extended to all those attending the Meeting to join in the trip to the famous Mammoth Cave on Thursday, October 16. Special rates have been obtained not only for the transportation to and from the Cave, but also for luncheon and a three-hour trip through this entrancing underground cavern with its 150 miles of charted passages, which annually attracts thousands of visitors. In it, among the things to be seen, are Echo River, the underground mystery stream in which are found eyeless fish; the Star Chamber in which the mineral formations in the vaulted room give the illusion of a starlit sky; seemingly bottomless pits; cathedral-like spaces and mineral structures akin to architectural creations. It is the largest of the caverns found in the cave regions and has been made into a National Park by the United States Government.

Those whose homes are south of Louisville could plan their return trip to include a stop at the Cave with the regular group.

Kentucky Hospitality Is Famous

Wives of the Louisville members have arranged a program of entertainment that will ably uphold Kentucky's reputation for hospitality. Plans have been made for one trip to the many scenic parts of the city and for another to include "My Old Kentucky Home" at Bardstown, the Lincoln Shrine at Hodgenville, and the famous stud farms of the Bluegrass.

Of course all of the women attending the Meeting will be more than welcome at the general luncheon on Monday, the dinner on Tuesday, the Horse Show and Barbecue, and the Cave trip.

It cannot be overemphasized that Louisville, stretching along the south bank of the beautiful Ohio River, and the surrounding Kentucky country possess not only historic attraction but reflect the particular charm of Southern life, where the art of gracious living has not been forgotten.

This A.S.M.E. Fall Meeting at Louisville is a "must" in your plans. It will give you a few days before the start of heavy winter schedules in which to enjoy yourself with an easy conscience. The technical program will challenge your interest—the social activities warm your heart!

Detailed Program

The detailed program of the meeting is given on the next two pages. It is of particular interest to note how many of the papers deal either directly or indirectly with problems of national defense.

Louisville Convention League

AIRPLANE VIEW OF LOUISVILLE, KY.

Louisville Convention League

THE SKY LINE OF LOUISVILLE, KY.

A.S.M.E. Fall Meeting Program

Louisville, Ky., Oct. 12–15, 1941

Headquarters, Brown Hotel

SUNDAY, OCTOBER 12

2:00 p.m.

Meeting of the Council

MONDAY, OCTOBER 13

9:30 a.m.

Fuels

What the Engineer Should Know About the Production of White Burley Tobacco, by L. S. O'Bannon

Evolution of Furnace and Superheater Design, by William J. Vogel

Rubber and Plastics

Design and Performance of Plastic Parts, by W. B. Hoey

The Provision of Production Facilities for Synthetic Rubber, by O. M. Hayden

Metals Engineering—Machine Shop

Modern Methods of Shell Forgings and Auxiliary Equipment, by Irwin Loewy

The Role of Induction Heating in Defense, by F. T. Chestnut

12:00 noon

General Luncheon (Women included)

2:30 p.m.

"Gateway to the South Tour" through Louisville, sponsored by the Women's Committee

Aviation—Oil and Gas Power

Manufacture and Processing of Aluminum Alloys, by Paul Zeigler

Air Filters for Airplane-Engine Protection, by William K. Gregory

Safety

Methods for Improving Industrial Hygiene, by James R. Allan

Drying

Developments of Drying Process in Switzerland, by R. Bernstein and A. Weisselberg

Drying of Agricultural Products, by H. L. Schmidt

8:00 p.m.

Management—Education and Training

Problems Connected With the Erection of New Plants: Indiana Ordnance Works, Charlestown, Ind., by W. O. Hauck

Wright Aeronautical Plant at Cincinnati, Ohio, by R. K. Brown and Russell T. Howe

Motion Picture Studies of Machine-Shop Operations and Practice and Visual Aids for Defense Training, by F. E. Brooker and John W. Barrett

Wood Industries—I

Variation in Shrinking and Swelling of Wood, by A. J. Stamm and W. K. Loughborough

High-Frequency Methods of Gluing Woods, by H. L. Smith, Jr., and Paul D. Zotter

Power—Fuels

Watts Bar Steam Power Station of T.V.A., by George B. Rich and Ralph T. Mathews

Method of Estimating Circulation in Steam-Boiler Furnace Circuit, by A. A. Markson, T. Ravese, and C. G. R. Humphreys

TUESDAY, OCTOBER 14

9:30 a.m.

Trip to Historic Shrines of Kentucky

Management

The Engineers' Responsibility for Depreciation, by F. W. Jackson

Depreciation Estimates in Appraisals of Manufacturing Equipment, by Paul T. Norton, Jr., and E. L. Grant

Smoke Abatement

Causes of Mortality of Smoke-Abatement Campaigns, by Thomas A. Marsh

Essentials of a Smoke-Abatement Program, by H. K. Kugel

Wood Industries—II

Resin-Bonded Door Constructions, by Tinsley Rucker, 3rd

Modern Timber Construction Methods in Europe, by E. George Stern

Power

Flood Protection of Canal Street Station, by A. G. Rosenbaum

Turbines for Power Generation From Industrial-Process Gases, by John Goldsbury and John R. Henderson

12:30 p.m.

Management Luncheon

"Free Enterprise and World Politics," by Walter White, U. S. Department of Commerce

2:00 p.m.

Plant Trips

American Air Filter Co. and Churchill Downs

Brown Forman Distillery Corporation

Louisville Gas and Electric Co.

Axton-Fisher Tobacco Co.

7:30 p.m.

Wood Industries Dinner

Symposium—Defense Work by Woodworking Industries

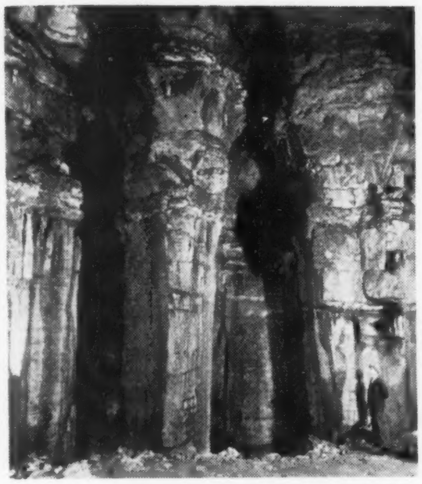
WEDNESDAY, OCTOBER 15

9:30 a.m.

Wood Industries—III

The Urea Treatment of Lumber, by J. F. T. Berliner

(Program continued on next page)



A GROTTO IN MAMMOTH CAVE

The Edge-Gluing of Veneers and Lumber, by H. K. von Maltitz and Roy Johnson

Critical-Pressure Steam Boilers

The Corrosion of Unstressed Specimens of Steel and Various Alloys by High-Temperature Steam, by H. L. Solberg, G. A. Hawkins, and A. A. Potter

Machine-Shop Practice

Manufacture of Shells, by M. F. Judkins
Industry Aids the Arsenals, by W. D. Bearce

Process

A Development in the Manufacture of Ice, by B. F. Kubaugh
The Application of the Girbotol Process to Industry, by B. D. Storrs and R. N. Reed

2:30 p.m.

Through the evening
Horse Show and Barbeque Dinner

THURSDAY, OCTOBER 16

Special trip through Mammoth Cave

St. Louis Defense Meeting

September 9–11, 1941

Hotel Chase

Tank Manufacture
Aviation
Chemicals
Plant Protection

Small Arms Ammunition
Electric Power
T.N.T. Manufacture
Production Machinery

Fuels and Lubricants
Foundries
Office Production Management

Wire or air-mail request will bring you complete details of this important program.

Plan to Be There!

Information on Heat-Treatment of Molybdenum High-Speed Steel

CONSIDERABLE demand has arisen for literature instructing metallurgists, heat treaters, and users as to a method for treating molybdenum high-speed steel to produce its highest efficiency. Because of the shortage of tungsten and instructions prohibiting the use of tungsten high-speed steel, when avoidable, it seems desirable to circulate the pertinent information. According to Bradley Stoughton, Chief, Heat Treating Equipment Unit, Tools Section, OPM, Washington, D. C., committees of experts have been appointed on:

(*a*) Heat-Treating of Molybdenum High-Speed Steels, consisting of Norman I. Stotz, chairman, W. H. Wills, F. Lloyd Woodside, J. H. McCadie, and J. Edward Donnellan, secretary.

(*b*) Furnaces and Controlled Atmospheres, consisting of C. I. Hayes, chairman, P. B. Crocker, W. M. Hepburn, Norbert Koebel, Karl Ness, and J. Edward Donnellan, secretary.

(*c*) Salt Baths, consisting of Artemus F. Holden, chairman, James McElgin, Joseph N. Bourg, W. J. Levy, and J. Edward Donnellan, secretary.

Preliminary and tentative reports have been prepared by these committees, which preliminary reports, when passed by the committee members, will be circulated among experts with the object of securing as much additional information on the subject as possible. Subsequently, final reports will be prepared by the committees, which reports will be printed and distributed to all interested persons. As soon as practicable there will also be projected meetings addressed by experts in many of the important centers of manufacture, by local chapters of the American Society for Metals. Besides other distribution, copies of the committee reports will be available at the aforementioned meetings.

[An article, "Molybdenum in Iron and Steel," by T. D. Parker, appeared in the November, 1940, issue of MECHANICAL ENGINEERING.—EDITOR.]

Wm. M. Sheehan Appointed to Standing Committee on Professional Divisions

W. M. SHEEHAN, General Steel Castings Company, has been appointed by President Hanley a member of the A.S.M.E. Standing Committee on Professional Divisions. He will have under his jurisdiction the Aviation, Management, and Railroad Divisions which comprise the Management and Transportation Departments of the Professional Divisions.

Instruments and Apparatus, Part 7 on Measurement of Power by Means of Dynamometers

Preliminary Draft of Information on Instruments and Apparatus Section on Measurement of Power by Means of Dynamometers Completed

THE important use of dynamometers in measuring the output of steam engines, turbines, and internal-combustion engines has caused the A.S.M.E. Power Test Code Committee on Instruments and Apparatus to prepare its Part 7 on the various types of dynamometers used for this purpose.

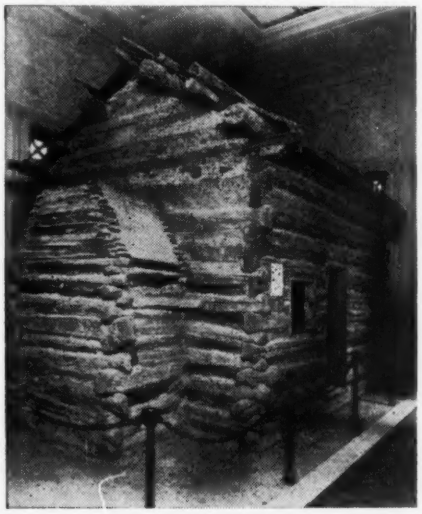
A tentative draft of this part is now completed, and the Committee will welcome criticism and comment on it by members of the Society as well as others interested. Copies may be obtained by addressing the Power Test Codes Committee, A.S.M.E. headquarters.

This part includes sections dealing with the various types of dynamometers which pertain to the principles of operation, the limits as to capacity and rotative speeds, precautions in their use, methods of cooling when required, and conditions that affect their accuracy.

Absorption dynamometers which transform the power into heat, thereby preventing its further use, include prony brakes, hydraulic or fluid-friction brakes, fan brakes, electromagnetic or eddy-current brakes, and electric generators.

Transmission dynamometers which measure the torque transmitted without preventing the use of power for the purpose intended include traction dynamometers, gear dynamometers, belt dynamometers, torsion dynamometers, and electric motors when suitably mounted.

Useful design information is given for the construction of prony brakes and air brakes, the latter type being more suitable for loading engines that are being run-in than for accurate measurement of their power output.



CABIN IN WHICH ABRAHAM LINCOLN WAS BORN, LINCOLN SHRINE, HODGENVILLE, KY.

(Excursion is planned to this shrine during A.S.M.E. Fall Meeting at Louisville.)

College Defense Training Enters New Fields

Title Being Changed to Conform With Broadened Program

WIDENING of the sphere of activity of the Engineering Defense Training program is emphasized by appointment by U. S. Commissioner of Education, John W. Studebaker, of three additional members to the committee of prominent engineering educators, advising staff members of the U. S. Office of Education, on broad policies relating to the training of defense workers by the Nation's colleges and universities.

To conform with the broadened scope of this program its title is being changed from "Engineering Defense Training" to "Engineering, Science, and Management Defense Training."

New Advisory Committee Members

New Advisory Committee members are Homer L. Dodge, dean of the graduate school, University of Oklahoma, Clare E. Griffin, dean of the school of business administration, University of Michigan, and N. W. Rakestraw, professor of chemistry, Brown University. Dr. Dodge will advise on matters relating to the training of physicists, Dr. Griffin on the training of production supervisors, and Dr. Rakestraw on the training of chemists.

Other members of the Advisory Committee who have served since last fall were listed in a note on page 841 of the November issue.

Institutions granting degrees for study in chemistry, physics, and business administration which the new appointees are to represent, are now eligible to give short, intensive training courses of college grade to present and prospective workers in industries and government agencies concerned with national defense.

Instruction Without Charge

Instruction under both the Engineering Defense Training and the Engineering, Science, and Management Defense Training programs is given without charge to persons with the necessary educational qualifications who are employed or employable in defense work.

Application for admission should be made directly to the institution giving the course desired. An extensive summer program is now under way in over 90 per cent of the nation's engineering colleges, and will be supplemented as rapidly as possible in the newly authorized fields.

Pitt Establishes Research Division in Engineering

ESTABLISHMENT of a research division in the Schools of Engineering and Mines at the University of Pittsburgh has been authorized by the executive committee of the Board of Trustees, Dean E. A. Holbrook announces.

Purpose of the division is to conduct research and investigation in engineering and technology of spedial concern to the industrial, engineering, and public interests of western Pennsylvania, Dean Holbrook explains. A number of research projects are under way already. The new division will unify and promote this work.

Management of the new division is vested in an executive staff composed of Dean Holbrook as director and heads of eight departments in the Schools of Engineering and Mines. This staff will be responsible for general policies governing the work of the division, including approval of material for publication at the conclusion of research projects.

Expansion of the present policy, whereby funds for conducting research and publication of results may be received from cooperating private and public agencies, will be undertaken, Dean Holbrook explains. The division will publish and distribute bulletins and circulars containing results of its researches.

A.S.A. Approves First Defense Emergency Standard

THE American Standards Association has announced the approval of its first Emergency Defense Standard. The new standard, which is for the machine-tool industry, sets up accuracy requirements for lathes.

The new standard describes a series of tests to be applied for checking engine lathes in respect to such matters as bed level; tailstockway alignment; spindle-center runout; leadscrew alignment; and in turning the work cylindrical when mounted in chuck or between centers. The accuracy requirements, stated in terms of maximum permissible variations, apply to three groups of engine lathes: toolroom lathes; engine lathes, 12 to 18 in. and 20 to 36 in., inclusive.

The requirements for accuracy of engine lathes originated with the engine-lathe group of the National Machine Tool Builders Association. Shortly after the A.S.A. had adopted its emergency procedure, the N.M.T.B.A. asked that this be applied to the proposed standard to expedite its approval and publication.

Accuracy of engine lathes will be published at an early date by the A.S.A. in a distinctive format to identify it as a Defense Emergency Standard. Copies will be available through the American Standards Association, 29 West 39th Street, New York, N Y.

A.I.E.E. Issues Report on Telemetering, Supervisory Control

A REPORT, "Telemetering, Supervisory Control, and Associated Circuits," has just been published by the American Institute of Electrical Engineers.

Corrected to December, 1940, this report summarizes a wealth of information concerning the electric telemetering and supervisory-control systems currently in use or commercially available in the United States, and includes a detailed discussion of the interconnecting circuits suitable for such purposes. Copies may be secured from A.I.E.E. headquarters, 33 West 39th Street, New York, N. Y.; price is 40 cents per copy to members of the Institute (80 cents to nonmembers) subject to a 20 per cent discount for quantities of 10 or more mailed at one time to one address.

A.S.M.E. Calendar

of Coming Meetings

October 12–15, 1941
Fall Meeting
Louisville, Ky.

October 30–31, 1941
Joint Meeting of A.S.M.E. Fuels and A.I.M.E. Coal Divisions
Lafayette College
Easton, Pa.

December 1–5, 1941
Annual Meeting
New York, N. Y.

March 23–25, 1942
Spring Meeting
Houston, Texas

June 8–10, 1942
Semi-Annual Meeting
Cleveland, Ohio

June, 1942
Oil and Gas Power Division
Peoria, Ill.

(*For coming meetings of other organizations see page 22 of the advertising section of this issue*)

N.E.M.A. Motor and Generator Standards

THE National Electrical Manufacturers Association announces the release of "NEMA Motor and Generator Standards," Publication No. 41–64, which supersedes Publication No. 38–49 released in 1938. This revision contains all the standards which have been approved to date covering motors and generators, including such information as standard dimensions, rating, tests, etc. Copies may be obtained from the National Electrical Manufacturers Association, 155 East 44th Street, New York, N. Y. The price is $3.50.

University of Arizona Sets Up Engineering Experiment Station

THE Board of Regents of the University of Arizona at the meeting held on June 28, 1941, decided to establish an Engineering Experiment Station in connection with the University, and appointed members of the faculties of the Colleges of Engineering and of Mines to staff positions, with G. M. Butler, dean of the College of Engineering, as director. Research on problems of particular interest to people in the Southwest will be started soon after the University opens in September.

(*A.S.M.E. News continued on page 690*)

Industrial Hygiene Foundation Meets Nov. 12–13

THE Board of Trustees of Air Hygiene Foundation of America, Inc., announces the change of the organization's name to Industrial Hygiene Foundation of America, Inc. Reason for the name change is to more clearly describe the Foundation's expanding activities and membership services for the protection of employee health. When the Foundation was organized emphasis was placed on silicosis, No. 1 industrial health problem at that time. With the rapid advances of industrial hygiene and the multiplication of new occupational health problems, the Foundation's work has steadily broadened.

A study is now under way, with the collaboration of the U. S. Public Health Service, to help reduce sickness absenteeism which is costing the heavy industries alone about one billion man-hours yearly. Other accomplishments include: Continuing studies of X-ray techniques for large-scale physical examinations in industry; studies of the control of toxic fumes and gases, including proper precautions in welding; a research, now in progress, to develop further practical data on exhaust ventilation for employee health protection; investigations in "protector" dusts, including aluminum, to combat dust diseases.

A "storehouse" of industrial health literature has been built up at the Foundation's headquarters in Mellon Institute. Current literature is digested each month for the information of the members and to keep them posted on progress. This digest covers about 300 journals in a dozen languages. Industrial-hygiene laboratory facilities are also maintained at Mellon Institute. The Foundation now has industrial hygienists spending most of their time in the field making surveys for member companies. These surveys show the presence or absence of potential health hazards. Where hazards are found, remedies are recommended.

The Foundation's sixth annual meeting will be held at Mellon Institute, Pittsburgh, on Nov. 12 and 13.

Men and Positions Available

Send Inquiries to New York Office of Engineering Societies Personnel Service, Inc. This service is operated on a cooperative, nonprofit basis, whereby those actually placed in positions by the Service agree to contribute to help maintain this service

29 W. 39th St. New York, N. Y.	211 West Wacker Drive Chicago, Ill.	57 Post Street San Francisco, Calif.	Hotel Statler Detroit, Mich.

MEN AVAILABLE[1]

MECHANICAL ENGINEER, 27, married. Six years' experience in heating, ventilating, layout, and design; desires permanent position in factory maintenance with possibility of development into production and management. Me-675.

MECHANICAL ENGINEER, professional, with proved inventive and executive ability. Long and thorough experience in invention and design of automatic machinery, chemical plant and equipment, automotive, special machinery. Me-676.

MECHANICAL ENGINEER, 32. M.I.T. graduate, with 8 years' industrial experience in production, maintenance, and erection of machinery. Now employed in textile industry, desires change to responsible industrial position. Me-677.

MECHANICAL ENGINEER, 24. Graduate New York University (Evening), July, 1941. Seven and one-half years' experience in photo-offset lithography. Seeking testing, research, and development position. New York City or vicinity preferred. Me-678.

MECHANICAL ENGINEER, 22, single, B.S. 1940. Honor graduate, believes hard work can somewhat offset lack of experience. Interested in design, does not shirk responsibilities. Will go anywhere in U. S. Me-679.

MECHANICAL ENGINEER with 20 years' experience in design and charge of engineering department. Familiar with Diesel engines and marine steam engines for commercial and Navy work with sufficient shop experience to supervise work and testing of machinery. Me-680.

MECHANICAL ENGINEER, approximately 40, thoroughly experienced in design, production, and plant management; capable of meeting the problems of development and manufacture and keeping machine plant functioning smoothly and efficiently. Prefer Middle West. Me-681.

PLANT SUPERINTENDENT, 33, married. Well-balanced experience in machine shop, sheet metal, forging, and assembly. Thoroughly familiar with planning schedule and time study. Established record for cost and scrap reduction and economical plant operation. Now employed. Me-682.

SALES EXECUTIVE ENGINEER, broad technical, business, and legal training, law degree, ten years designer and engineer steel plants, twelve years machine-tool salesman, dealer, sales manager, general manager leading machine-tool concern. Me-683.

RESEARCH AND DEVELOPMENT ENGINEER, M.E., licensed, married. Creative ability, broad practical experience as machinist, instructor in machine work, chief engineer large waterwheel manufacturer, consultant hydroelectric power development, domestic stokers. Metropolitan area. Me-684.

[1] All men listed hold some form of A.S.M.E. membership.

POSITIONS AVAILABLE

ENGINEER to take full charge of mechanical and production management in plant manufacturing metal fittings from sheet metal and wire. East. Y-8559.

MECHANICAL ENGINEER, young, who has majored in industrial management or had experience in manufacture of glassware. Applicant will be trained through various departments of plant and possibly given special work which will lead to control of production, supervision. Headquarters, Illinois. Y-8576.

ERECTION ENGINEER, mechanical, or chemical, or combination. Engineer with technical degree who has had considerable experience in erection of large chemical and mechanical plants. Must be capable of organizing large staff including personal assistants, controlling erection with own men. Plant will be located in the Mountain States, and work will extend for two years' duration. $6000–$7000 year. Y-8606.

PURCHASING AGENT. Must be engineer with broad training. Would prefer engineer with some practical experience, particularly in electrochemical operation, such as chlorine production. Must have some purchasing experience since he will be called upon to buy wide variety of materials; should be reasonably familiar with suppliers in general, with particular reference to electrical equipment, crushing and conveying equipment, refractories, cast iron and steel piping, and general construction. Must have executive ability and be able to organize complete purchasing department. Should have experience in drawing of contracts. $6000 to $10,000 annually. Will be called upon to work in Middle West for about 2 months and then move to Mountain State location for permanent residence. Y-8608.

PERSONNEL DIRECTOR. This position will be filled by man with substantial training in personnel direction and labor relations. Educational background should be based either on engineering or industrial lines. Should have at least 2 or 3 years' experience in personnel direction, and, specifically, should have considerable experience in employment of technical men. Organization will eventually be composed of some 4000–5000 employees. Must be prepared to assume all responsibilities for hiring of all junior staff, foremen and workmen, and must undertake the direction of the safety department, handle labor relations, attend to the welfare department and trade relations. Must be capable of keeping comprehensive record with modern methods. Preference will be given to man with wide experience in Mountain States industries and one with experience in chemical and metallurgical plants. $5000–$8000 year. Y-8609.

PLANT MANAGER, graduate mechanical engineer, who understands pressed-steel operations, such as making of steel cabinets, lockers, shelving, reflector shades. Should also be toolmaker and designer and able to supervise work of toolmakers. $4680 year. Connecticut. Y-8623.

MANUFACTURING SUPERVISOR, mechanical engineer, familiar with fine instrument work, to take charge and develop manufacturing end of these new products for established manufacturer. Must have good sound tooling experience. $4000–$5000 year. Connecticut. Y-8629.

(*A.S.M.E. News continued on page 692*)

One machine tool manufacturer — looking for "the best" in spindle steels — has standardized on Chromium-Molybdenum "4145".

This low cost alloy steel meets the stringent demands of wear resistance and toughness put upon the spindle to produce long-lived accuracy in lathe-produced parts.

Write for our free technical book, "Molybdenum in Steel".

CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.
MOLYBDIC OXIDE—BRIQUETTED OR CANNED • FERROMOLYBDENUM • CALCIUM MOLYBDATE

MOLY

Climax Mo-lyb-den-um Company
500 Fifth Avenue · New York City

ASSOCIATE PROFESSOR industrial engineering to head department of industrial engineering and industry. Experience in this field. Starts Sept. 1. \$3000–\$3300 for 9 months. South. Y-8633.

MECHANICAL ENGINEER, 35–45, experienced in manufacture of all types of pressure vessels, boilers, welding, etc. Must be familiar with A.S.M.E. Boiler Codes and A.S.T.M. Codes for office engineering work. Up to \$5000 year. New York, N. Y. Y-8640.

MECHANICAL ENGINEER, about 33–42. Should hold M.E. degree and be able to control workshops producing welded structures, vessels, and pipes, turning, drilling, and smithing. Also to control works measuring-instruments department, garages, general small stores, and plant service pipe lines. Some plant-maintenance experience desirable. \$6000–\$7000 year. Must live in Mountain States. Y-8647.

INDUSTRIAL ENGINEER, 30–45, well experienced in time and motion study, who has definite experience in plating, buffing, and polishing of bronze and brass castings. Start at \$400 month, with increase at end of three months and additional increase at end of six months provided work is satisfactory. Eastern Ohio. Y-8658-R-206-C.

MECHANICAL ENGINEERS, college graduates, with at least 4 or 5 years of experience in manufacture of small products in company manufacturing radio receivers and equipment, telephone switchboards and apparatus, and electrical sound systems. Must be familiar with modern manufacturing methods, especially those pertaining to forming and finishing of metals and preferably with some experience with plastics. Must be able to design tools for production as well as product itself for economical manufacture. N. Y. State. Y-8692.

MACHINE DESIGNER, 30–40, graduate mechanical engineer for machine-development department; 3 to 4 years' experience in design of light and medium-weight machinery desired. Ability to exercise originality in design and to make neat and accurate drawings. Position permanent. \$2700–\$3300 year. Ohio. Y-8704-C.

GRADUATE MECHANICAL ENGINEER, 30–45, to do some research development work, with at least 8 years' experience along metal-working lines. Should also have experience in ferrous forgings, both hot and cold, design of dies, machine design, and metallurgy. Will do original design and development of forged-steel shapes carrying on from conception of idea to point of production. Company manufactures forged-steel fittings for welded piping. \$3600–\$6000 year. Kentucky. Y-8717.

ENGINEER to take charge of engineering department of consulting firm. Experience in refrigeration and heat exchange essential. Basic knowledge of electricity and structures required. Should be able to make engineering service and power-plant surveys for food industries. Position permanent, not defense work. New York, N. Y. Y-8718.

CHIEF ESTIMATOR, graduate mechanical engineer, for armament business. Experience in machine-shop operations, such as process engineering, tool designing, superintendent or assistant, chief estimator. Duties will be to study blueprints or armament on which quotations are to be submitted and make recommendation as to which parts his company should manufacture and which should be let out on subcontract; also to prepare cost estimates on machining, tools and dies, and assembly on all such work contemplated. Have forceful but pleasant personality. \$5000–\$6000 year. Headquarters, New York, N. Y. Y-8735.

ENGINEERS, preferably graduate mechanical engineers, who have had experience as superintendent, assistant, production manager, purchasing agent, or assistant in connection with machine-shop operations. Will be required to act as liaison between company and subcontractors; to interpret to the subcontractors what is required of them to assure prime contractor adhering to schedule; to anticipate difficulties and delays on part of subcontractors; and to do whatever necessary to solve difficulty and keep shipping schedules. Job is with primary contractor making armaments and is typical machine-shop and assembly operation. Salary, \$5000–\$7000 a year. Headquarters, New York, N. Y. Y-8736.

INDUSTRIAL ENGINEERS, young. Prefer men with some type of engineering training and 5 or 6 years' industrial engineering experience. \$3000–\$3600 year. Pennsylvania. Y-8756.

PERSONNEL MANAGER, 30–45, experienced in handling factory personnel, safety engineering. Permanent. \$4000–\$6000 year. New Jersey. Y-8762.

MECHANICAL ENGINEER, 30–35, with 5 to 10 years' experience in machine-shop design. Permanent. \$6000–\$7000 year. Chicago. Y-8765.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after September 25, 1941, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the Secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and transfer to Member.

NEW APPLICATIONS

For Member, Associate, or Junior

BLISS, CONRAD DEK., Norwood, N. J. (Re)
BODINE, ALBERT G., JR., Burbank, Calif.
BURGESS, WALTER E., Rutherford, N. J. (Rt)
BURNS, WILLIAM J., Buffalo, N. Y.
CANT, DAVID A., Tulsa, Okla. (Rt & T)
CLOUGH, ALVAH B., Easton, Pa.
COHEN, LESTER, Englewood, N. J.
DAMON, RALPH S., Garden City, N. Y.
DAVIES, WM. M., JR., Pawtucket, R. I.
DENTLER, ARNOLD E., Hinsdale, Ill.
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FLEISCHER, IRVING, Kearny, N. J.
FLOREK, RALPH S., Youngstown, Ohio
GILG, FRANK X., New York, N. Y. (Rt & T)
GILL, JAMES P., Latrobe, Pa.
GREEN, THOMAS A., Cleveland Heights, Ohio
HACKETT, HAROLD N., Ballston Lake, N. Y.
HALLQUIST, GUNNAR C., Chicago, Ill.
HAMILTON, NEWELL, Beaver Falls, Pa.
HOLDING, ROBERT W., Chicago, Ill.
HOWELL, JESSE M., Schenectady, N. Y.
IMMERFALL, ROBERT J., Chicago, Ill.
JASKI, FRANK E., Hilton Village, Va.
KUBELLE, MILTON M., Jackson Heights, N. Y.
KUNTNY, GREGOR W., Naugatuck, Conn.
LUSTIG, ERIC W., New York, N. Y.
MARTZ, LAWRENCE S., Detroit, Mich.
McCOOL, HARRY S., Dallas, Texas
MOORE, MORGAN M., Washington, D. C. (Rt)
MUTTER, EDW. C., Providence, R. I.
PETERSON, HENRY F., Rockford, Ill.
PETERSON, LLOYD E., Chicago, Ill.
POND, CLARENCE E., Roanoke, Va.
SCHNEIDER, GEORGE R., Little Rock, Ark.
SWAUGER, JOHN S., Wilkinsburg, Pa. (Rt)
TRUNDLE, GEORGE T., Shaker Heights, Ohio
WHEELER, FRANK G., W. Springs, Ill. (Rt & T)
WIGGS, GORDON L., Montreal, Que., Canada

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HERBERT, LESLIE E., Baltimore, Md.
MAYER, MALVIN J., New York, N. Y.
PARLETTE, H. LESLIE, JR., Pittsburgh, Pa.
REASER, WILLIAM E., Easton, Pa.
ST. CLAIR, FREDERICK G., University City, Mo.

A.S.M.E. Transactions for August, 1941

THE August, 1941, issue of the Transactions of the A.S.M.E. contains:

- Significance of Coal-Ash Fusing Temperature in the Light of Recent Furnace Studies, by E. G. Bailey and F. G. Ely
- Flow Processes in Underfeed Stokers, by M. A. Mayers
- Lubrication of General Electric Steam Turbines, by C. Dantsizen
- Stress and Deflection in Reciprocating Parts of Internal-Combustion Engines, by R. L. Boyer and T. O. Kuivinen
- Some Particulars of Design and Operation of Twin-Furnace Boilers, by John Blizard and A. C. Foster
- Condenser Tubes and Their Corrosion, by C. W. E. Clarke, A. E. White, and C. Upthegrove
- Thermometric Time Lag, by Rudolf Beck
- Vaporization Inside Horizontal Tubes, by W. H. McAdams, W. K. Woods, and R. L. Bryan
- Recommended Code of Procedure for Fatigue Testing of Hot-Wound Helical Compression Springs, by C. T. Edgerton